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NOTES.

The decision of the Select Committee of the House of Commons in regard to the Central London Railway Bill shows that the various objections urged against the scheme by its thirty odd opponents were in the eyes of the Committee mutually destructive. The proviso that no prospectus is to be issued, nor any capital applied for, until the City and Southwark line has been for some time in operation, is an eminently reasonable one. Upon the degree of success which attends the working of these two London underground electrical railways, the immediate future of electric traction in this country will in a large measure depend; and it is not, therefore, to be regretted that the Committee thought fit to defer the commencement of the Central London line until the only other one of its kind has succeeded beyond question. Both the electrical and the engineering portions of the scheme are in good hands; and the promoters of the Bill are to be congratulated that "the precious plea of postponement" did not unduly influence the House of Commons Committee.

In spite of the very able statement of Mr. Fletcher Moulton, the deputation from electric lighting companies that waited on the President of the Board of Trade last Friday received but cold comfort. Sir Michael Hicks-Beach's assurance that the Board of Trade will not permit a local authority to use the powers given it "to keep the electric light out of its town" is hardly satisfactory in view of the fact that local authorities have been allowed to hold Provisional Orders for seven years without making use of them. The deputation were evidently of opinion that the obstructive tendencies of local authorities should be checked automatically by the insertion of suitable clauses in their Provisional Orders rather than by the spasmodic action of the Board of Trade. But, as we have already said, the deputation were bidden to be of good cheer, and trust to the benevolent intentions of the department over which Sir Michael Hicks-Beach presides.

Electric sparks, which but a short time ago were chiefly regarded as a source of amusement, have now been found capable of several useful applications. Not only have they, in the hands of Hertz and Lodge, contributed largely to the advancement of electrical theory, but they have shown themselves specially suited for the production of instantaneous photographs of rapidly moving objects. Mr. C. V. Boys, who has lately turned his attention to the subject, showed the results of his well-known manipulative skill to the Physical Society on Friday last. The successive forms assumed by moving water-drops were shown in an admirable series of photographs taken not only with a single slow spark, but even with the oscillating spark itself, a photograph being obtained at each oscillation. The periodical character of the spark is of course a valuable characteristic for purposes of this kind. The only marvel is that light, lasting for such a very short time, should be found sufficient to produce the chemical effects necessary for photography; although the suggestion of Lord Rayleigh, that it is to be accounted for by the richness of the spark in ultra-violet ray and to the absence of any absorbing lenses, seems to contain the solution of the difficulty.

The phenomenon of residual discharge which occurs with condensers has sometimes been attributed to an actual penetration of the electricity into the substance of the dielectric. M. Bouty, in a recent investigation of the subject, has experimented on mica condensers formed of very thin plates. It was assumed that the positive and negative electricities, soaking into the dielectric from the electrodes, would meet and neutralise each other if the plates were sufficiently thin. A constant current would therefore pass under the influence of a steady electromotive force, and the dielectric would behave like a conductor. It is a deduction from theory that for condensers having the same dielectric the product of the capacity and dielectric resistance should be constant. The experiments of M. Bouty appear, however, to disprove this law, which, as far as we are aware, has not before been put to any practical test.

About twenty volts were applied to a subdivided condenser in series with a graphite resistance of several hundred megohms, the current flowing being measured by the reading of a Lippmann's electrometer shunted to the latter. The current, although variable on first applying the battery, was found to become quite steady after two hours, and its value remained unaltered while the capacity was varied between one microfarad and a tenth of that value. As the resistance offered by the condenser was always very much greater than that due to the graphite, it seems necessary to conclude that the current is not due to the actual passage of electricity across the dielectric, since in that case the resistance of the condenser would have been found inversely proportional to the capacity. The delicacy of the tests may be judged from the fact that the

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smallest current perceptible corresponded with a specific resistance of the mica equal in ohms to the resistance of a column of mercury one square millimetre in section and long enough for light to require 3,000 years to traverse it.

THE experiments seem to show that the conduction of dielectrics is due solely to extraneous surface leakage arising from imperfect insulation of the electrodes or to flaws in the material. M. BOUTY accounts for the phenomenon of residual discharge, which causes the variations in the current on first applying the battery, to progressive change in specific inductive capacity during that time. It, however, appears easier to follow MAXWELL in accounting for the separate effects by the simple assumption of a heterogeneous dielectric. In view of the great practical importance of insulators, it is desirable that these experiments should be repeated, for the results are at variance with recognised views.

THE Mutual Telephone Company certainly starts on its career with excellent intentions, both financial and electrical. Promotion money and commissions are to be unknown to it, and the long-suffering telephone subscriber is promised complete metallic circuits, an improved system of central exchange switching, and greatly reduced charges. Cheaper rates and an improved service are, of course, very attractive; but it remains to be seen whether the National Telephone Company, under the stimulus of threatened competition, will not cut the ground from under its rival's feet by the simple process of offering its clients still greater attractions. In this contingency the Mutual Company, even with the many advantages it possesses, will have a somewhat formidable task in front of it. However, as it is proposed to immediately commence operations in Manchester, the National Telephone Company's counterblast cannot be long delayed.

THE misfortune which has so persistently pursued the Maxim Weston Electric Company has culminated in something ap proaching a fiasco. By the latest balance-sheet of this Company, which will be found in another column, it will be seen that the Company's sole income during the past year amounted to the large sum of £41. 13s. for transfer fees and interest. It is worthy of note also, that the retiring Directors do not offer themselves for re-election, while the auditors do.

ELECTRICAL engineers in this country have frequently to complain, so we are given to understand, of the vagaries of fire insurance inspectors due to their lack of electrical knowledge. Much the same difficulty exists across the Atlantic; and the remedy arrived at there is simplicity itself, namely, the electrical educating of the inspector by the electrical engineer whose work he is to pass. Such, at least, is our reading of the following paragraph in our Boston contemporary *Modern Light and Heat*:—"A meeting is announced to take place between electrical men and insurance men in New York, to complete arrangements for a number of insurance inspectors to be examined and instructed by first-class electrical engineers, so as to be able to determine correctly the quality of all electrical work."

THE lecture on the remarkable repulsion experiments of Prof. ELIHU THOMSON which will be delivered before the Society of Arts on Wednesday next by Dr. FLEMING promises to be of considerable interest. These experiments have a most direct bearing upon alternate-current motor problems, and open a wide field for practical discovery. The apparatus exhibited by Prof. THOMSON at the Paris Exhibition has been lent to Dr. FLEMING for the occasion; and Mr. ERNST THURNAUER, the engineer of the European Thomson-Houston Company, will come over from Paris to assist in carrying out the experiments.

The City of London and Southwark Subway Bill.—This Bill was read a third time in the House of Commons on Wednesday last.

Newcastle.—The large gas lamps at the Cattle Market and the Central Station Square were replaced last week by arc lights, the current being supplied by the Newcastle and District Electric Lighting Company.

Proposed Spanish Submarine Cable.—Tenders for the laying of a cable connecting Spain with the isles of Puerto Rico and Cuba are about to be invited by the Spanish Government. The proposed cable will be one of the longest in existence.

Institute of Marine Engineers.—On Tuesday last Mr. R. E. Crompton gave his first lecture on "Practical Electrical Engineering," before the Institute of Marine Engineers. The second lecture, on the same subject, will be given on Tuesday, May 20th, at 7:30 p.m.

Southampton.—The Special and General Works Committee of the Southampton Harbour Board reported at the last meeting of the Board in favour of the adoption of electric cranes. This proposal gave rise to considerable discussion, and the matter was finally referred back.

Electric Traction in Coal Mines.—In the Richterschact pit, Laurahütte, the Allgemeine Elektricitäts Gesellschaft has just laid down at its own cost a mineral tram line. A similar course has been adopted by the Deutschen Elektricitätswerke of Aix-la-Chapelle at Antonienhütte.

Obituary. — Mr. James Nasmyth, the famous inventor of the steam hammer, died on Wednesday morning last, at Bailey's Hotel, Queen's-gate. Mr. Nasmyth was born in Edinburgh on August 19th, 1808, and he was consequently in his eighty-second year at the time of his death.

Public Building Lighting.—The electric lighting of New Scotland Yard, which is being carried out by Mr. A. A. Campbell Swinton, will require no less than 1,100 lamps, and the total length of wire both for electric lighting and communication purposes will amount to over twelve miles.

Eastern Extension, Australasia, and China Telegraph Company.—This Company announce that the laying of their new Sydney-Nelson cable has this week been successfully completed, thus duplicating the cable communication between Australia and New Zealand, and increasing the security of the service.

The Frankfort Exhibition, 1891.—We understand that the Managing Committee intend making a special display of the uses to which electricity may be put as a motive power, with a view of demonstrating the superiority of electric motors to steam engines for many purposes for which the latter are now employed.

The Electro-Harmonic Society.—The annual general meeting of this society will take place on Wednesday, May 21st, at 4:30 p.m., at 4, The Sanctuary, Westminster, S.W. The society, which commenced with 115, now at the close of the fourth season consists of 278 members. Fifty members were elected during the past year.

Telephonic Extensions in the North.—An important addition to the telephonic system in Scotland has just been provided by the completion of a system of telephonic communication between Edinburgh, Glasgow and Dundee. The new trunk wire is about 100 miles long, and is conveyed under the Tay by a cable two and a-half miles in length.

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The Copper Market.—According to statistics furnished by Messrs. H. Merton, the visible stocks of copper on April 30th were 90,230 tons, compared with 124,447 tons on the same date last year, and 91,938 tons a month ago. The deliveries for the past month have been 10,050, compared with 11,535 tons a month ago, and 8,509 tons on April 30, 1889.

Eastbourne.—At the last meeting of the Town Council, a letter was read from the Board of Trade, stating that on the explanations forwarded in regard to special circumstances, they would now agree to a Provisional Order being granted to the Eastbourne Electric Light Company, at the maximum rate of 10d. per unit, as requested by the Electric Light Company.

The Ward Electric Car.—The Ward Electric Car Company announce that an experimental omnibus can be seen by appointment at their newly-opened premises in Dacre-street, Westminster, S.W. The Company have contracted with the Electrical Construction Corporation for their first line of electrical omnibuses, which will run between King's Cross and Charing Cross.

Royal Society.—The following Papers were down for reading at the Royal Society yesterday:—"On the Heating Effects of Electric Currents," No. 4, by Mr. W. H. Preece; "On Barometric Oscillations during Thunderstorms, and on the Brontometer, an instrument designed to facilitate their study," by Mr. G. J. Symons.—The annual *conversazione* of this Society will be held on Wednesday next.

Appointment Vacant.—The Council of the University College of South Wales and Monmouthshire are prepared to appoint a Professor of Mechanical Engineering in the new Department of Engineering of the University, with a stipend of £300 per annum. Further particulars will be found in our advertisement columns, and all information can be obtained from Mr. Ivor James, at the University, Cardiff.

The Telautograph.—We are informed that the Comptroller of Patents has decided that the autotelegraphic inventions of Professor Gray and Mr. Thomas O'Brien are practically the same, and has refused to grant a patent to Professor Gray unless he withdraws his principal claim, and inserts a disclaiming clause in the specification to the effect that his patent does not claim or cover anything that is described in the specification of Mr. O'Brien's patent.

Reduction of Telegraph Tariffs.—The River Plate Telegraph Company has reduced its charges from 30c. for 10 words and 10c. for each additional five words, and 10c. per code word to any telegraph station in the Argentine Republic. The Western and Brazilian line has also reduced its charges between Buenos Ayres, Europe, and New York; and the International Telegraph Company at Montevideo has reduced its tariff between that city and Buenos Ayres to 40c. for 10 words.

The Institute of Medical Electricity.—Viscount Templetown has accepted the chairmanship of this Institute, in the place of Mr. William Lant Carpenter, who, owing to ill-health, has resigned his office, to the great regret of all concerned. Lord Templetown is a well-known electrician, and has taken strong interest in the Institute of Medical Electricity since its inception. There is no doubt that under his rule the scientific thoroughness of the Institute will be maintained, and its usefulness further developed.

Hardingstone Local Board.—At the end of last month Major Marindin held an inquiry with reference to the Hardingstone Local Board's refusal to consent to the application for a Provisional Order by the Northampton Electric Light and Power Company. The Inspector's report is to the effect that the promoters have not shown sufficient cause for dispensing with the consent of the Hardingstone Local Board, and he recommends that the district of the Hardingstone Local Board be struck out of the area of supply scheduled to the Order.

New Telegraph Route between Bombay and Calcutta.—The opening of the Bengal-Nagpur Railway, says the *Indian Engineer*, will give a new telegraph route between Bombay and Calcutta. A copper wire is to be laid the whole distance (over 1,100 miles), and messages will be signalled direct, as is now the case between Bombay and Madras. The wire has already reached Nagpur, and it will soon be extended to Calcutta. It will greatly relieve the traffic on the existing lines, and messages passing between Calcutta and Europe *viâ* Suez will be more expeditiously disposed of.

Bolton.—A special meeting of the Town Council was held on Wednesday for the purpose of considering the advisability of applying for an electric lighting Provisional Order under the Electric Lighting Acts, 1882-88. Alderman Miles, Chairman of the Gas and Lighting Committee, moved the resolution, and in doing so said that at least thirty large towns intended to apply for Provisional Orders during the next Session; and seeing that a company (the Lancashire and Cheshire House-to-House Company) had applied for powers, the Gas Committee thought it best to get the matter into their own hands. After some debate the resolution was unanimously agreed to.

The McDougall Motor.—This motor is of the inverted horse-shoe type, with a Gramme armature. There is one point worth noticing in the McDougall motor, namely, the general use of mitis metal for the magnetic circuit. Recent experiments in Germany have shown that it is possible to secure a cast-iron of even better magnetic properties than most wrought-iron, and experiments tried on the mitis metal, of which this motor is constructed, have shown a similar result. Not only is it equal in magnetic permeability to forgings, but many specimens of it are distinctly better—in some cases by as much as 50 per cent. These valuable properties make mitis metal likely to take an important place in electrical manufactures, for the ability to avoid expensive tool work by making casts of such excellent magnetic material will go far towards compensating for the extra expense of the material itself.

Thermo-magnetic Apparatus.—The two following pieces of laboratory apparatus have been devised by J. Stefan to exhibit thermo-magnetic phenomena. The first, a thermo-magnetic pendulum, consists of a nickel segment attached to the end of a strip of brass, which is movable round a horizontal axis, and is provided above this axis with a sliding weight. When at rest the nickel segment lies between the poles of a horse-shoe magnet. On heating one end of the segment, however, that end immediately moves upwards, and if the heating is continued a regular oscillation may be started. The second piece of apparatus is merely a nickel disc which can rotate around an axis passing through its centre of gravity. The poles of a horse-shoe magnet cover a portion of the rim, and on heating another portion the wheel commences to rotate, and under favourable conditions can be made to revolve at the rate of 60 revolutions a minute.

The International Telegraph Conference.—A circular has been issued by a number of Manchester merchants calling attention to the meeting of this Conference next week, and stating that unless the mercantile community interests itself by making timely remonstrance with Government they may find the limit of code-words reduced to eight letters. They have also signed a memorial to the Manchester Chamber of Commerce requesting that representations may be made by the Chamber to the Postmaster-General that the British Government do not sanction any changes in the existing rules of the International Telegraph Convention which will lead to the curtailment of the use of legitimate words, not exceeding ten letters, of eight authorised languages.—According to the Berlin correspondent of *The Times*, Herr von Stephan, Imperial Minister of Posts, means to submit a proposal to the International Telegraph Conference for the adoption of a uniform international telegraph tariff.

The Wellingborough and District Tramroads Bill.—This Bill came last week before a Committee of the House of Lords. The objects of the Bill are to extend the lines of the Wellingborough Tramroads Company from Bozeat to Olney, and there to form a connection with the Midland Railway, and to run on from thence to Irchester and Higham Ferrars and Rushden. It is proposed to work the whole system by electricity. The only petition against the scheme was that of the South of England Telephone Company, who demanded that provisions should be inserted for the protection of their lines. Dr. John Hopkinson and Mr. W. H. Preece were called in support of the provisions

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proposed by the Telephone Company. The Committee finally decided to pass the Bill with the insertion of the proposed clauses, with the addition that, if required by the Telephone Company, words should be added to the effect that the promoters should bear a share of the expense of protecting existing telephone lines.

Thermo electric Investigations. — Some experiments on thermo-electric currents between amalgamated zinc and zinc sulphate were recently described by Herr K. A. Brander. The primary object of the investigation was to determine the relation between the electromotive force developed and the difference of temperature between the electrodes. The electrodes, of amalgamated zinc, were placed in two vessels communicating by means of a syphon, and filled with a solution of zinc sulphate. One of these vessels was kept at the temperature of the place of observation, while the temperature of the other was gradually raised. The *Journal* of the Chemical Society says the author found that, within the limits of errors of observation, the electromotive force was proportional to the difference of temperature, until this difference exceeded 20·45° C., after which the electromotive force appeared to increase rather more rapidly than the temperature difference. Experiments show that concentration of the zinc sulphate solution increased the electromotive force.

The Board of Trade and Electric Lighting Companies.—In the House of Commons on Thursday last week Mr. Kimber asked the President of the Board of Trade whether, as the Board had struck out at the instance of local authorities Clause 6 of the Board's Model Order prohibiting a supply of electricity beyond the area of supply, he was prepared to make a similar concession to electric lighting companies; and whether he would grant to companies the same concession, namely, an appeal to the Board of Trade in the matter of compulsory works, which the Board made to local authorities at their recent interview with the officials of the Board of Trade on April 24th last. Sir M. Hicks-Beach, in reply, said that his answer to the first inquiry must be in the negative, seeing that the position of a company limited to an area, and possibly with other companies in adjoining areas, is distinct from that of a local authority having jurisdiction over their own local district, even though this should be larger than their area of supply. As regards the second inquiry, he was prepared to treat companies and local authorities alike.

Royal Institution.—At the general monthly meeting of this Institution, on Monday, May 5th, the following gentlemen were unanimously elected as officers for the ensuing year:—President, The Duke of Northumberland, K.G.; treasurer, Sir James Crichton Browne, M.D.; secretary, Sir Frederick Bramwell, Bart, M.Inst.C.E. The following Vice-Presidents for the ensuing year were also announced:—Sir Frederick Abel, Mr. William Crookes, Mr. Edward Frankland, Mr. William Huggins, the Right Hon. Earl Percy, Mr. Basil Woodd Smith, Sir James Crichton Browne, treasurer; Sir Frederick Bramwell, Bart., secretary. Prof. Tyndall was elected honorary professor of natural philosophy, and Lord Rayleigh was elected professor of natural philosophy. The annual report for the year 1889 testified to the continued prosperity of the Institution. The real and funded property now amounts to above £82,000, entirely derived from the contributions and donations of the members; 51 new members were elected in 1889; 63 lectures and 19 evening discourses were delivered in 1889; and a total of 822 volumes were added to the library in the year.

Wire Construction in Cities.—In a recent number of the New York *Electrical World* Mr. A. A. Knudson describes a system called the Aerial Conduit method, patented in 1881 jointly by Mr. O. F. Smith and himself. An ordinary I-shaped iron girder is employed, enclosed in a sheet-iron case in such a manner as to form a conduit with two compartments. The conduit is supported overhead on hollow wrought-iron pillars from 18ft. to 20ft. high, placed 60ft. apart. The structure is to be made ornamental; and the smaller size conduit, which is but 6½in. by 8in., will contain as many as 500 telephone or telegraph wires and 20 or more electric light wires. In distributing wires from the structure, it is intended to run the wires down the hollow iron pipes just below the flagstones of the sidewalk, thence through a pipe to the basement of buildings. By this method an important point is secured in the way of accessibility to any part of the line. When wires are to be placed inside, the doors are unlatched and slung down for the distance required and the wires or cable laid in, thus obviating the necessity of drawing them through conduits.

The Scharf Gas Battery.—The Scharf gas battery consists of a gas-tight vessel, preferably of cylindrical form, capable of holding the gases under very considerable pressure. The idea is to work with two gases in pairs, or with one gas and a liquid—one gas or liquid forming the positive, and the other the negative element in the cell. Among the gases of one class named by Mr. Scharf as suitable for his purpose are hydrogen, water gas, generator gas, coal gas, and all the vapours of the more or less volatile hydrocarbons of mineral oil. In the other class are placed air, oxygen, chlorine, fluorine, and the liquids hydrogen peroxide and nitric acid. Two typical gases for use in this way would be coal gas and oxygen, which would be compressed and stored separately. Each gas is admitted to one side of a carbon diaphragm, or rather, between two adjacent carbon diaphragms, contained in the vessel already described; and the plates of carbon are separated into pairs by alternate spaces filled with a gas and with asbestos saturated with acidulated water. All the intervals of even numbers in the pile would thus contain one gas, and all the others another of opposite electrical condition. In this way a pile of any number of cells might be built up.

Electromotors in Engine Works.—Messrs. Denny and Co., engineers, Dumbarton, have the tools in their pattern shop driven by a 20 horse-power electromotor. The dynamo is placed in the machine shop and driven from the ordinary shafting. From the generator to the motor in the pattern shop the current is conveyed through two cables about ⅜in. diameter. If this had not been done, a separate small engine and steam piping of great length would have been required. In the boiler shop of the same firm, says *Industries*, there is a still more interesting example of the application of electricity as a motive power. This is Rowan's patent electric boring machine, for drilling the rivet holes through boiler shells *in situ*. Anyone who has watched drilling tackle at work, especially in shipyards, must have noticed how much time was absorbed in fixing the clamp into position. Rowan's electric borer not only has a small motor to drive the drill, but holds itself up against the plate by means of a pair of powerful electro-magnets. Messrs. Denny are about to put electromotors to other uses in their yard, amongst the earliest of which will be the driving of all the sewing machines in their large upholstering department, at present driven by the feet of the female operators.

The Silvertown Dry Cell.—The following are the averages of a number of tests on a new dry cell now being manufactured by the India Rubber, Gutta Percha and Telegraph Works Company:—

Cell.	E.M.F.	Internal resistance.	Hours working through an external resistance of 7 ohms before falling to half potential.
Large size...	1·5	·528	369
Small do....	1·51	·336	123

The weight of the cells when complete is, in the case of the large size, 4½lb., and for the small size 2lb. 7oz. The cell is specially designed for use where the battery is liable to shaking or rough handling, such as on board ship, for field telegraphy, and similar work, where it would be found inconvenient to use the ordinary cells. Care should be taken in mounting a battery of these cells to prevent one cell from touching another, and they should stand upon a base of some insulating material, such as glass or dry wood; and for efficient working this cell is not recommended to be used in positions where the temperature is high. When the cell appears to have been worked out it is, as a rule, only necessary to fill it up with a saturated solution of sal ammoniac and let it stand for some time, when the solution may be poured out and the cell wiped dry at the top; it will then be found to have recovered.

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THE EDINBURGH EXHIBITION.

The Edinburgh International Exhibition, as we announced in our last issue, was opened with due ceremony on May 1st by the Duke and Duchess of Edinburgh. The many thousands who have already passed the turnstiles have no doubt set at rest any uneasiness which may have existed in the minds of the executive committee on the score of the financial success of the Exhibition; and if the visitors throng for the most part in the Concert Hall, or around the band-stand in the grounds outside, it is certainly not for want of more solid attractions within the buildings. The display of electrical apparatus, for instance, is very creditable, and, including as it does examples of all the more important applications of electricity, is well calculated to impress even the most casual observer.

The selection of a site more than a mile distant from the centre of the city would probably have militated somewhat against the success of the Exhibition had not the means of communication been so complete. As it is, in addition to being thoroughly accessible, the site at Merchiston is picturesquely situated, and is of ample size, extending to some 50 acres, with a further large reserve of 40 acres, and will, moreover, shortly be placed in direct railway communication with the Forth Bridge. The Exhibition buildings, which are almost entirely of wood, and painted with a variety of hues, comprise the Main Building, 700ft. long by 250ft. wide; the Machinery and Electric Hall, 680ft. by 150ft.; a fine Concert Hall, Picture Galleries, a Railway Court, and a French Electrical Annexe. In the grounds, which are very extensive, there are, or rather we should say there will be, several interesting applications of electricity. A telpher line, about half-a-mile long, is being laid down by the United Electrical Engineering Corporation, who are also responsible for the electric railway which is to connect the Exhibition stations of the Caledonian and North British Railways; and, as we have already announced, four electric launches, engined by Messrs. Immisch and Co., will ply between Edinburgh and the Exhibition along the Union Canal.

The lighting of the buildings and grounds, which has been entrusted to the Brush Company and to Messrs. King, Brown, and Co., has been very creditably carried out; and although all the circuits were not being run at the time of our visit, there was no lack of light. The arc lighting is entirely in the hands of the Brush Company, whose installation comprises 365 2,000 candle-power lamps, 283 of which are used for interior illumination, and 82 for the lighting of the grounds, where the lamps are for the most part arranged in groups of three on 65ft. plain iron tubular masts. These masts have a graceful appearance; they stand without stays, and have all the electrical conductors and necessary gear for raising and lowering the lamps contained in the interior of masts. To avoid anything like a complete breakdown in any one part of the Exhibition, the circuits have, as usual, been arranged so that alternate lamps are fed from different dynamos. The leads from the dynamos are carried to a switchboard, where they terminate in pairs of contact hooks; the terminals of the various circuits consist of pairs of stirrups, so that it is only the work of a moment to couple any dynamo to any circuit. The Concert Hall, Reception and Refreshment Rooms are lighted by incandescent lamps of 200, 50, and 16 candle-power, the larger ones being Sunbeams. This part of the lighting is in the hands of Messrs. King, Brown, and Co., and is very effective. The dynamos and engines engaged in the lighting are all situated in a fine open space, 120ft. by 80ft., in the centre of the Machinery Hall, and form the most striking feature of the Exhibition. The first thing which attracts attention are a pair of magnificent horizontal compound engines by Messrs. Robey and Co., of Lincoln, one of which is capable of developing 320 and the other 260 horse-power. The larger of these engines is fitted with trip expansion gear, and has a fly-wheel 15ft. in diameter; and the lesser has a fly-wheel 12ft. in diameter. These engines, which have been especially made for the Exhibition, are employed in driving the whole of the arc dynamos used in lighting both the Exhibition buildings and the grounds. The power is transmitted by ropes to counter-shafting, and thence by belting to the dynamos. Behind these engines is situated the boiler-house, in which there is a battery of five Galloway boilers, of a combined capacity of 2,500 horse-power. From these boilers practically the whole of the steam required for driving purposes is supplied, at a pressure of 110lb. to the square inch. Messrs. King, Brown, and Co.'s incandescent light dynamos are driven direct through belting by two fine engines of the Westinghouse type, which have been specially constructed for the occasion by Messrs. Alley and Maclellan, of Glasgow. One of these is of novel design, and its performance will be closely scrutinised, inasmuch as an unusual degree of economy in working is anticipated.

Turning now to the electrical exhibits, we shall confine ourselves in this preliminary notice to making a brief mention of those exhibits which are actually complete, and hope in subsequent issues to describe the more important and interesting in detail. One of the most interesting and valuable exhibits in the Electrical Section is that of the British Post Office. Not only does the Post Office differ from a large number of electrical exhibitors in having its stall absolutely complete, but the value of its exhibit is considerably enhanced by the simple but useful addition of a brief clearly-printed explanatory ticket which is attached to every piece of apparatus. The catalogue, which, we may remark *en passant*, is hardly as reliable a guide to the Exhibition as could be wished, in most instances merely informs its readers that such and such a piece of apparatus is a dynamo, transformer, or secondary battery, as the case may be, leaving them to evolve from their inner consciousness the probable use of these mysterious contrivances. We would suggest, therefore, that other electrical exhibitors would do well to imitate the Post Office, and ticket their apparatus with explanatory labels for the benefit of the non-technical public. On the Post Office stall there are to be seen examples of almost every type of telegraph instrument in use, or formerly in use, in the United Kingdom, ranging from Cooke and Wheatstone's earliest needle telegraph of 1837 down to the Wheatstone automatic of to-day. Close to the Post Office stall, and adjoining the French Annexe, is the fine exhibit of the Eastern Telegraph Company, which comprises, amongst other things, the latest and earliest types of Sir William Thomson's syphon recorder, a Saunders lightning guard, and a model of the improved bow-gear fitted to the Company's cable steamer "John Pender." The Consolidated Telephone Construction and Maintenance Company make an excellent display of their well-known domestic and portable telephonic apparatus. The young firm of Prentice Napier and Co., of Stowmarket, show four moderately-sized well-finished dynamos, in which all wires are protected from dust and moisture by metal casings. One of the dynamos is connected direct to a high-speed engine, by Easton and Anderson, of Erith. Messrs. Ernest Scott and Co., of Newcastle, make a very good display with direct-coupled dynamos for ship-lighting; they also exhibit a small 10-unit "Tyne" alternator and some "Tyne" transformers. A noticeable feature of Messrs. King, Brown and Co.'s stall is a very compact compound engine, coupled direct to a 200-light dynamo, running at 300 revolutions. We may mention here that Messrs. King, Brown, and Co. have one or two motors driving exhibits in various parts of the building; and it is to be hoped that several more will be installed before the Exhibition closes. The India Rubber, Gutta Percha, and Telegraph Works Company show a fine compound engine, by Messrs. Musgrave and Sons, of Bolton, coupled direct to a fine "Silvertown" dynamo. The exhibits of the Electric Construction Corporation, and of Messrs. Immisch and Co., promise to be the most interesting of their kind in the Exhibition. The Electric Construction Corporation show a fine accumulator car, with motor and cells complete; a 10-unit alternator, with engine; a large variety of secondary batteries, and a set of the ingenious automatic devices employed in the E.P.S. system of distribution. Messrs. Immisch will exhibit tramcar, launch, mining, and other motors, and an "Ingersoll" percussion rock-drill worked by an Immisch motor.

The display of electric light cables and wires is very complete, most of the leading firms exhibiting. Minor electrical apparatus, such as battery jars, insulators, bells, switches, cut-

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outs, arc-light carbons, artistic fittings, &c., are very much to the fore, the exhibits being generally more forward than those of the heavy engineering firms. The display of electrical measuring instruments is not so good as might have been expected, though Mr. James White, of Glasgow, has a fine case containing three of Sir William Thomson's current-balances, a vertical electrostatic voltmeter, a multicellular electrostatic voltmeter, a magneto-static current meter, and an ampere-gauge; and away in the North Court Prof. James Blyth has another case containing current-weighers and other instruments.

Apart from the fine engines engaged in driving the electric light dynamos, and the various engines to be seen on exhibitors' stalls driving dynamos direct, there are comparatively few steam-engines in the Machinery Hall. Messrs. Ruston, Proctor and Co. exhibit half a-dozen of their well-known engines, including a 16 horse-power compound semi-fixed engine, suitable for temporary electric lighting work. The display of gas and petroleum engines, on the other hand, is remarkably good, a fact which has been particularly noticeable at all recent exhibitions. In addition to the several engines in use in various parts of the Exhibition for driving exhibits, Messrs. Crossley Bros. show no less than twelve "Otto" engines, ranging from 33 horse-power to ½ horse-power. They also exhibit a 10 horse-power high-speed engine, designed specially for electric lighting work, the running of which is so even as to render unnecessary the heavy fly-wheel disc usually employed when a dynamo is driven by a gas-engine. Messrs. Dick, Kerr, and Co. show six of their "Griffin" engines, ranging from 12 horse-power nominal to ½ horse-power nominal. The two single-acting vertical engines of 1 horse-power nominal and ½ horse-power nominal respectively which this firm show are combined with water-tank on one base, and have a very compact and workmanlike appearance. Messrs. Priestman Bros.' exhibit is intended to show a complete private electric light installation, worked by an oil engine, and comprises a 5 horse-power nominal and a 2 horse-power nominal engine, a 2-unit "Tyne" compound-wound dynamo, accumulators, and other accessories.

From this rapid glance at the principal exhibits it will be seen that the display in the Electrical Section is fairly representative and comprehensive; and, as soon as the exhibits are all in their places and the electric tramcars and launches are running, and electric welding, electric tanning, and the Elmore process are to be seen in operation, it may be anticipated that the Machinery Hall and the French Electrical Annexe will attract their due share of the visitors who throng to the Exhibition. The idea of the present Exhibition originated, we believe, with Mr. A. R. Bennett; and the energy which has characterised the proceedings of those who undertook to carry out the scheme has certainly resulted in bringing it to a successful issue.

THE WALLER-MANVILLE SYSTEM OF ELECTRIC TRACTION.

The opposition that any overhead system of urban electric traction is certain to meet with in this country from local authorities, landowners, and others interested in preventing the obstruction and disfigurement of our streets by poles and wires renders it very desirable that English electrical engineers should devote their attention to overcoming the defects that have hitherto militated against the general adoption of the accumulator and conduit systems. As regards accumulators, the skill and money which have been lavished on them during the past three or four years have, indeed, transformed the accumulator car from an expensive toy into a commercial possibility. But although a storage cell has been evolved which is capable of withstanding with a tolerable degree of success the trying mechanical and electrical conditions of tramcar work, neither its output for weight nor its durability have been so greatly increased as to render accumulator traction an altogether satisfactory solution of the question. Neither can any conduit system which has been introduced up to the present be said to have proved an entirely satisfactory substitute for overhead wires. If a closed conduit is used, complicated apparatus must be provided for temporarily bringing a surface rail into circuit during the passage of the car over such rail. In all "open" conduit systems hitherto tried the conductor is buried in the conduit, and cannot be got at without considerable difficulty. In some systems a bare rigid conductor is used, supported at short intervals by separators, the current being collected by means of a brush of some description dragged upon the conductor, and pressed thereon either by its own weight or by means of springs. In other systems of open conduit, such as the Lineff, an insulated conductor is used having bare contact points attached to it at intervals. A flexible band of some description (of a greater length than the distance between the contact points) is suspended from the car so as to be always in contact with one or more of these points.

To overcome in some measure the defects of bad connection between the car and the conductor, difficulty of repair, poor insulation, &c., is the main object of the Waller Manville system. The improvements proposed relate entirely to mechanical details, and the system is consequently applicable to any known method of electrical distribution.

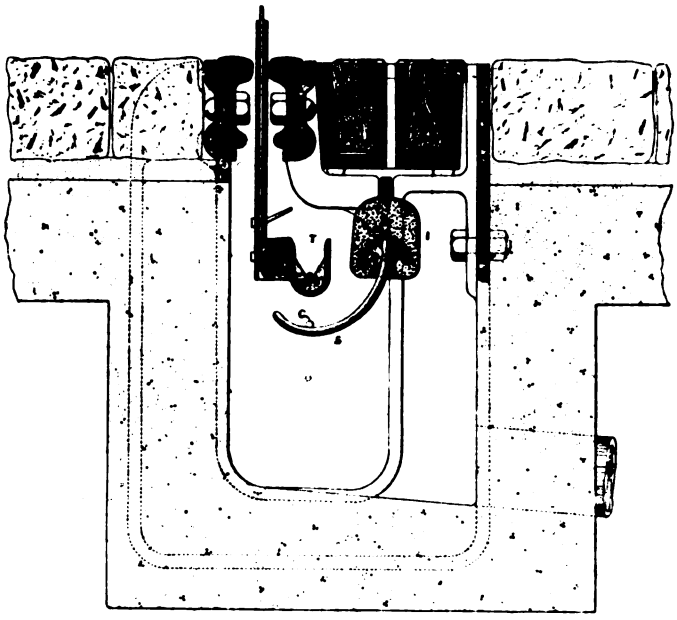

FIG. 1.—Waller-Manville System. Single Conductor. Cross-section through Hatchway.

The essential feature of the system is the employment of a flexible conductor sufficiently small to permit of its being placed in, or withdrawn from, the conduit through the slot. The conductor being flexible, the supports can be at long intervals of about 30ft.; and can therefore be placed in side openings to the conduit itself. By this means space is provided for large and efficient oil insulators. Removable covers are provided to these side openings or "hatchways," giving ready access to the insulators. The insulators are mounted in such a manner that on removing the cover they can at once be lifted out. The collecting arm is designed so that the shank can be withdrawn through the slot, and the collector proper (or brush) through any hatchway. Under ordinary conditions the conductor simply rests on supporting arms without being attached thereto. When it is necessary to firmly attach the conductor to its support, as, for instance, on sharp curves, absolute flexibility is still maintained, as the supports are so designed that whilst rigidly resisting either a longitudinal or a lateral strain, the same freedom of upward movement is allowed as in the case of the conductor itself when unattached. Simple automatic apparatus is provided at intervals to maintain a constant strain upon the conductor. The current is collected by means of a U-shaped collector in which the conductor runs; the collector lifting the conductor off the ordinary supports during its travel, and, in the case of those supports to which the conductor is attached, lifting the support itself.

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A reference to the annexed drawings will explain the arrangements adopted in this system. Fig. 1 is a cross-section through a hatchway, and shows the ordinary form of curved supports

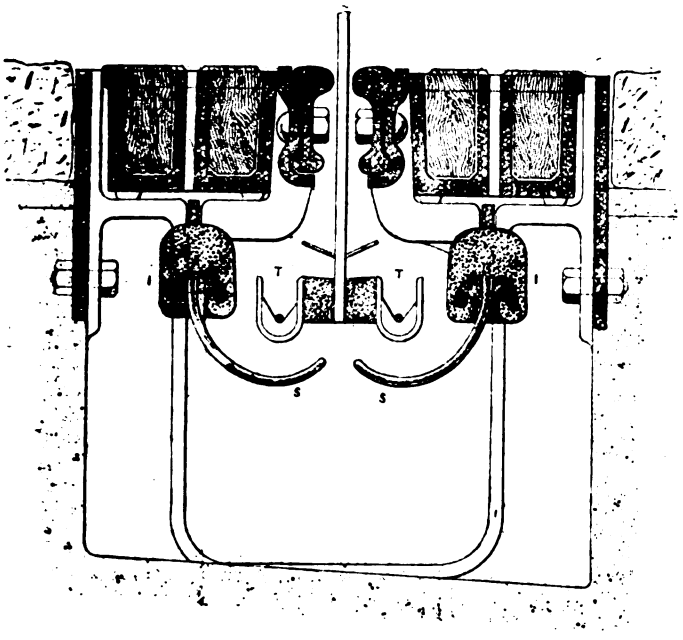

Fig. 2.—Waller-Manville System. Double Conductor. Cross-section through Hatchway.

on which the conductor C rests, and the moulded mica oil insulator I to which this support is attached. The conductor is shown lifted off the support by the collector T. Fig. 2 is

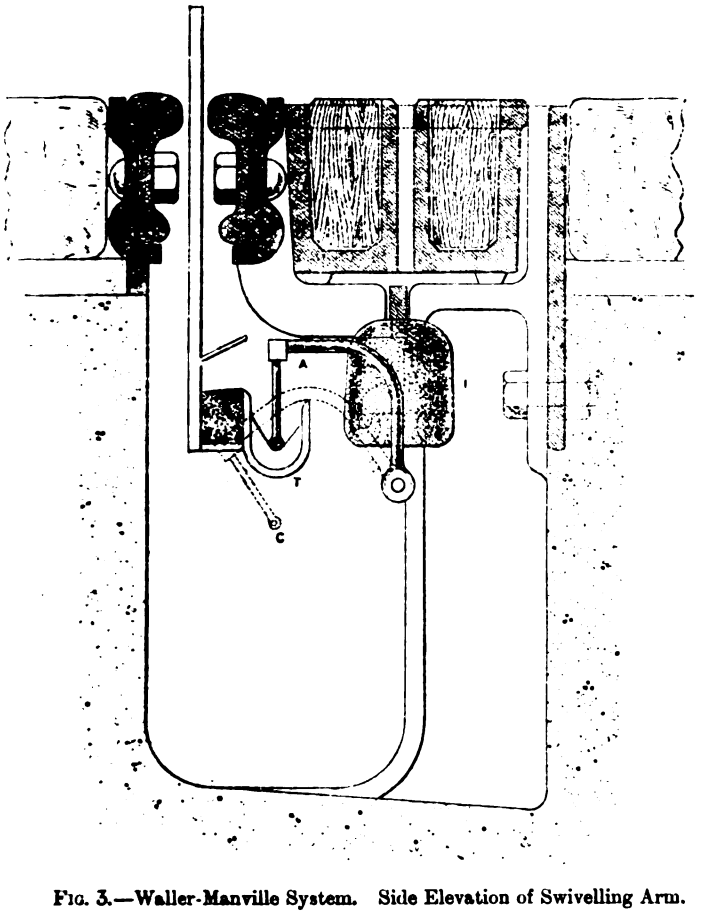

Fig. 3.—Waller-Manville System. Side Elevation of Swivelling Arm.

similar to Fig. 1, but shows the arrangement for two conductors in the tube. In Fig. 3 we have a side-elevation of the arrangement adopted at sharp curves, and which consists of a swivelling arm mounted on oil insulators. It will be observed that the conductor is held by this swivelling arm A, both being lifted by the collector, thus maintaining the flexibility of the conductor as regards upward movement, while rigidly resisting either a longitudinal or a lateral strain. Figs. 4

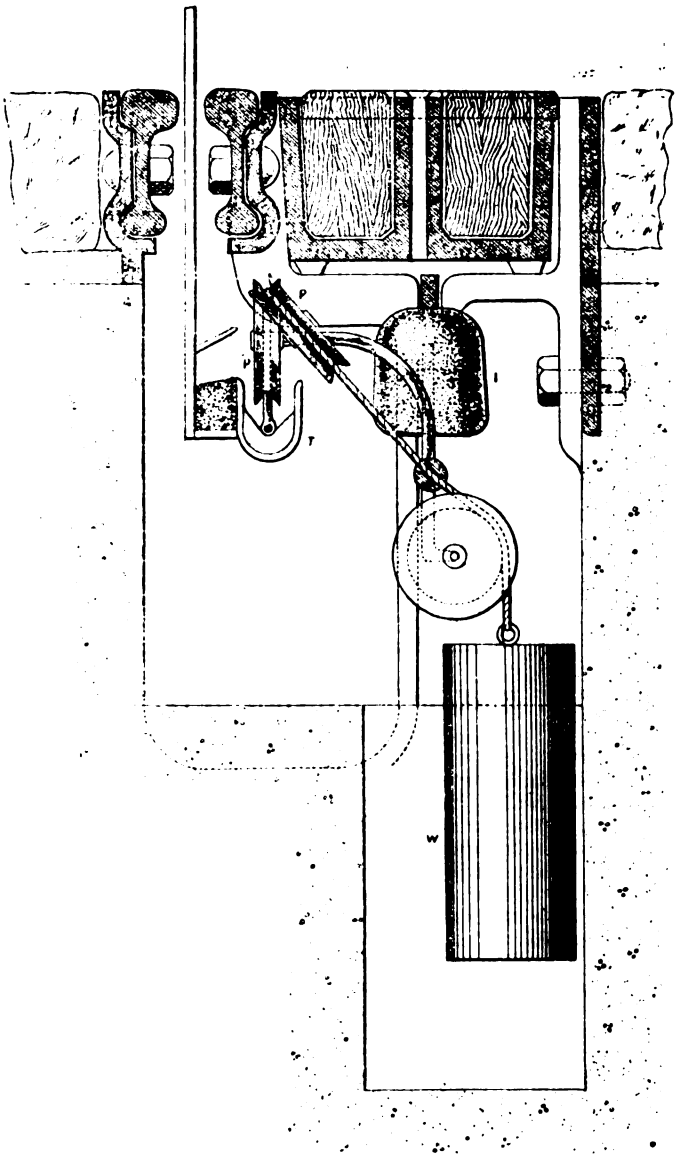

Fig. 4.—Waller-Manville System. Side Elevation of Straining Gear.

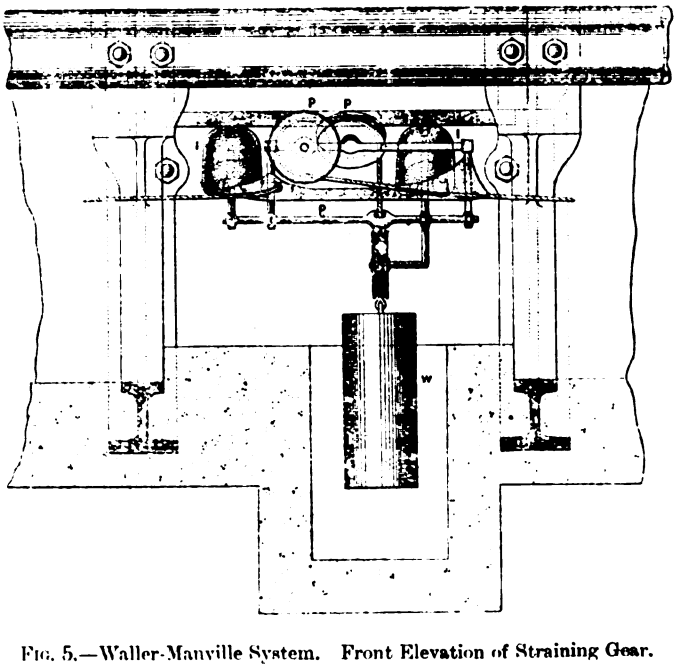

Fig. 5.—Waller-Manville System. Front Elevation of Straining Gear.

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and 5 show respectively a side and front elevation of tension or straining gear. This consists of a gun-metal plate, P, mounted on two swivelling arms, and supported by oil insulators, I I, and provided with small pulleys, *p p*, so arranged that the conductor, or cat-gut cord in continuation of the conductor, is led to one side, so that a balance-weight, W, can be attached thereto. This weight serves to keep the sag of the conductor between its supports constant in all changes of temperature. As the pulleys are arranged on the swivelling arm, the whole apparatus is free to lift in a similar manner to the single swivelling arm, the conductor being led through an eye in the shaft on which the apparatus revolves; the upward or downward movement of the tension frame in no way affects the length of the conductor, and consequently no resistance to this movement is caused by the weight of the counter-balance. This tension-gear would only be required at long intervals, occurring, say, every quarter of a mile.

Of the practical value of these devices, it is, of course, impossible to speak with confidence until they have been actually tried on a commercial scale, which, indeed, we understand will shortly be the case. The method of effecting contact between the conductor and the collector, however, seems likely to prove very effective; and the employment of large oil insulators at long intervals will certainly tend to increase the working insulation of the line, so that, apart from its ingenuity, the system devised by Messrs. Waller and Manville contains several elements of practical success.

ELECTRIC TRACTION DATA.*

BY A. RECKENZAUN.

Of the various questions connected with electric traction the branch of which I have the honour of calling your attention to to-night, appears to me fundamental to a complete knowledge of the subject. It relates mainly to tractive force and mechanical resistances on tramways. It is a subject which is not as fully appreciated by electrical engineers as it should be, although it forms the very basis of street locomotion; and I venture to say that future improvements in the economy of electric traction will in a large measure depend upon minute attention to details relating to this branch of the science. The very existence of tramways as substitutes for the common road is concentrated in one point, viz., the reduction of tractive resistance to a minimum.

It is a well-known fact that the traction expenses on horse tramways constitute about two-thirds of the entire working expenses, and it has long been the aim of engineers to find an economical mechanical substitute for animal power. Electricity has found great favour with tramway men in the United States, and there is every probability of similar developments in Europe at a not distant date. Improvements can only be brought about by experience, and experience must be gained in actual practice and by careful observation. These, again, can be supplemented by data obtained from those who preceded us; and it is my intention to bring, in a condensed form, such data, from which you will be able to draw your own conclusions, and which will guide you in future and progressive efforts.

In order to provide facility for traction, we must have a solid permanent way, and excellent rolling surfaces. The practical value of a good rolling surface can scarcely be over-estimated. The rails must be rigid, parallel, and fixed to solid foundations. In America flat step rails without grooves are used; these offer less resistance to traction than grooved rails; but, as a rule, they are not so solidly laid as English rails. According to Mr. D. K. Clark, the resistance to traction on an ordinary railway may be as low as 6lb. per ton; but so low a resistance cannot be obtained with grooved rails, which are exposed to the incidents of mud, grit, stones, and dirt, and which, moreover, have frequent and sharp curves.

Mr. Henry Hughes deduced from experiments on tramways a tractive resistance of about 26lb. per ton; often more, occasionally less. Such high resistances as these are readily accounted for when it is considered that the flanges of the wheels frequently take a bearing on the bottom of the grooves, or on the dirt embedded therein, at the same time that the wheels roll on the surface of the rail; for thus the wheel rolls on two different radii simultaneously, and grinding of surfaces in contact must result. It may also occur that one wheel is running on its proper bearing surface, whilst the other, belonging to the same axle, has its flange touching the bottom of the groove, when by virtue of different circumferential velocities additional friction is introduced. Sometimes the rails are a little out of gauge. All these circumstances augment the tractive force requisite with grooved rails. The horse, if it could speak, would be a good witness, but failing his verbal evidence, the dynamometer has been consulted. Better than the mechanical dynamometer, however, is the ammeter. A dead-beat ammeter indicates instantly the slightest variations of tractive resistances; and I venture to say that it will be through the judicious and more frequent applications of this instrument that material improvements both in the permanent way and in the rolling stock of electric tramways will be effected.

Probably the most interesting and complete tests with horse cars were those made by M. Tresca. He proved, experimentally, that the groove in the rail was the direct cause of a large portion of the resistance to traction. An ordinary car with its four flanged wheels was propelled over the tracks of the Paris-Versailles tramway, and it was found that the average tractional resistance amounted to $\frac{1}{100}$th of the gross weight, or 22·4lb. per ton. Subsequently two of the flanged wheels, both on one side of the car, were removed and replaced by flangeless wheels, when the resistance, all other things remaining the same, amounted to only $\frac{1}{177}$th of the weight, or 15½lb. per ton. The gross weight of car and passengers was 5·67 tons. These experiments show conclusively that at least half the power is wasted in friction between the sides of the groove and the wheel flanges.

The force required to start a tramcar and to get up speed is necessarily greater than the force required to maintain a given speed uniformly. It was found that the starting force is from four to five times that necessary for running on the level road. Curves also increase the resistance very much. In dry weather, on curves of 50ft. radius, the resistance to traction is doubled, and on those of 35ft. radius trebled; but when the rails are wet, this resistance, due to curvature, is considerably reduced. Water, plenty of water, on the rails acts as an efficient lubricant, and you will see by statements later on the general effect of wet rails. Short wheel bases, bogies, or radiating axles, render motion on curved rails easier, and flexible axle boxes are now greatly favoured, especially in the United States, for the same reason.

The effect of gradients is a matter of simple calculation. It is the maximum gradient on a given line which determines the size and power of the electric motor. Allowing 22·4lb. tractive force per ton, we should have to exert a pull of 134·4lb. with a six-ton car on a level road. This, at the rate of seven miles an hour, or 616ft. per minute, would give us 2·5 horse-power effective on the axles. If we have to overcome a gradient of 1 per cent., or 1ft. in 100, the resistance due to gravity will also be 22·4lb. per ton; therefore we shall require about 5 horse-power to pull this car up a gradient of 1 in 100. With a 2 per cent. rise the power will be three times as great as on the level, and, roughly speaking, each per cent. of grade demands as much energy as the propulsion of a given weight on a horizontal road if the speed is to be constant. On steep gradients, however, it is customary to run slower, whereby some of the energy is saved at the expense of time.

The time at our disposal will not permit of descriptions of particular systems of electric traction, nor of the relative merits of each, and we shall confine ourselves entirely to statistics on tractive force, no matter how this force is transmitted; and we shall merely consider the question of moving a given load on a given track by means of the electric current. In order to ascertain the amount of energy used on electric cars I have made, in conjunction with the Electric Car Company of America, a long series of systematic tests both on an experimental track built for this purpose, as also on the public roads under all sorts of conditions of traffic. Whilst on the experimental track we could run at any speed we liked, and without stoppages; on the public streets we were confined to the speed of horse cars in front and behind us, besides taking up and putting down passengers and regulating our vehicle to the general traffic of some of the busiest streets of Philadelphia.

This experimental track was laid in an irregularly shaped yard as shown on the diagram No. 1, and it was intended to represent as difficult a line as is likely to occur in actual practice. Its entire length was 1,005ft., the ends being so joined that the cars could circulate continually. Five and a quarter journeys round this track represented a mile run. There were four curves, two of 50ft. radius, one of 33ft. and one of 100ft. Tangent with the 33-foot curve was a gradient of 4·98 per cent. rise, which descended on the other side at the rate of 5 8 per cent., and joined the curve with a radius of 100ft. On this track we carried out tests and recorded observations which may be counted by the hundred thousands. The following figures relate to experiments made with a car in the autumn and winter of 1887-1888. The vehicle was an ordinary 16 foot two-horse car, with two axles, one motor, and a set of storage batteries. It weighed, with several men on board, 5·3 tons; its wheel base was 6ft., and one axle only was driven by an electric motor with intermediate spur gearing.

The rails were the ordinary American flat rails, grooved only at and near the curves, which represented a large percentage of the

* Paper read on Wednesday, April 30th, before the Old Students' Association of the City and Guilds of London Institute.

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entire track. With a set of 84 cells of a nominal capacity of 150 ampere hours, this car made 230 trips round this track, representing an aggregate of 43·8 miles with one charge of batteries. The car was only stopped and started fourteen times. The actual running time was 6¼ hours, giving an average speed of seven miles an hour.

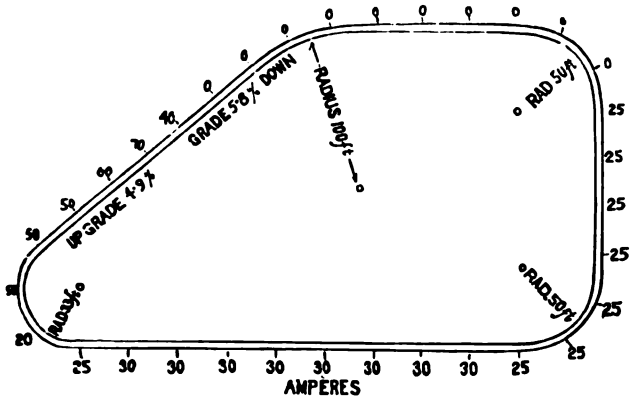

Fig. 1.

At the commencement the electromotive force of the cells on closed circuit was 160 volts, and at the end 145·2 volts, the average from actual measurements was 157 volts. The maximum current used on the steepest grade was 70 amperes at starting; on

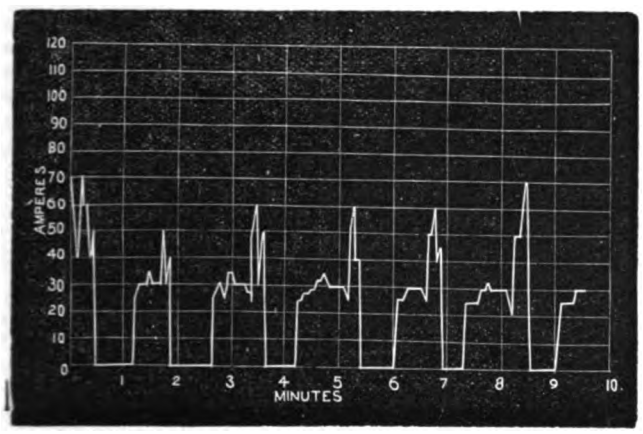

Fig. 2.

the curve or grade it rose to as much as 120 amperes. The average current consumed was 22 6 amperes, which corresponds to 141 ampere hours taken out of the battery. The current on the level road fluctuated between 18 and 25 amperes. The diagram No. 1 representing this track has marked upon it the current rates used at the various points of the journey. It will be observed that the car ran by momentum during a considerable portion of the journey, this momentum being acquired during its downward movement upon the 5·8 per cent. gradient, the brake being only slightly applied, and the stoppages during this experiment, as I have said, were few.

A mean of 4·75 electrical horse-power was thus expended, giving a consumption of 29·69 horse-power hours supplied by the battery; and the maximum energy given off at any moment was 10,500 watts, or 14 electrical horse-power. Allowing an average efficiency of 75 per cent. in the motor, and 85 per cent. in the gearing, we obtain a total efficiency of nearly 64 per cent. between the motor terminals and the axle, or about 3 horse-power available for traction. Thus the mean tractive force throughout the 43·8 miles run was 160lb., or about 30lb. per ton. This is very low, considering that out of the entire distance we had only 21 miles of tolerably level track, the rest being made up of 3·4 miles of 33ft. curves, 7·07 miles of 50ft. curves, 3·64 miles of 100ft. curves, and 4·05 miles of ascending grades of 4·98 per cent. On the other hand, there were 3·8 miles of descending grades of 5·8 per cent., which furnished momentum right along the 100-foot curve until the car passed completely into the upper 50-foot curve on the right hand side of the diagram. Converting the work into ton-miles, which is probably the most rational way of comparing figures, we get $5·3 \times 43·8 = 232·14$ ton-miles at an expenditure of 29·69 horse-power hours, and this gives nearly 7·78 ton-miles per horse-power hour. We have obtained much better results than this with a subsequent car containing various improvements, and, on one occasion, this larger car made 63 miles on the experimental track, each horse-power hour producing 10·9 ton-miles; but these are exceptional feats, and our present object is to consider practical results corresponding with everyday work—industrial results, in fact.

Three men, each well trained for his work, were necessary for these tests, and their respective duties were as follows:—One man took charge of the switch in front of the car and the hand-brake; in fact, he performed the ordinary function of a driver, taking care that the car moved at regulation speed on the level, that it did not "race" down grades, nor go too slowly up the inclines, and that it took the curves with safety. The second man, with a timepiece in his hand, counted the number of round trips and recorded the same; he also took voltmeter readings at equal intervals. The third attendant had the more difficult task of reading the deflections on the ammeter and writing down the values. In order to ensure uniformity in the time between each reading, and also take as many readings as possible, one has to learn to write down a certain number of figures in a given time, putting down ciphers, to fill up time when the ammeter needle is at zero. The number of observations written down during the 43-mile test was close upon 7,500, or one reading every three seconds. Considering the rapid variations in the current on uneven tracks, it is very important that readings are recorded at the shortest possible intervals in order to arrive at a correct average. The specific gravity of the cells was tested before starting, when they were fully charged, and it averaged 1,186 degrees. At the end of 6¼ hours, when the cells were practically discharged, the density fell to about 1,126 degrees. The accumulators were then recharged for six hours at the rate of 30 amperes when the electrolyte assumed its original specific gravity. It is impossible to keep the acid in every cell at the same density, there are always slight differences, and we had to take the mean of the entire number of cells to ensure accuracy. Diagram No. 2 represents the currents used during six journeys round the experimental track, and this was virtually repeated throughout the tests, except when stopping and starting. Now compare this with diagram No. 3, showing the current variations out in the crowded streets. You will observe a number of tall narrow peaks running down to the zero line at frequent intervals. During these intervals the car was either stopping or running by momentum. The vertical lines in this diagram represent minutes and seconds, and the horizontal lines amperes measured on the car during the entire journey from 23rd-street to the Exchange in Philadelphia and back to the Grayaferry depôt, and from thence again to its starting point,

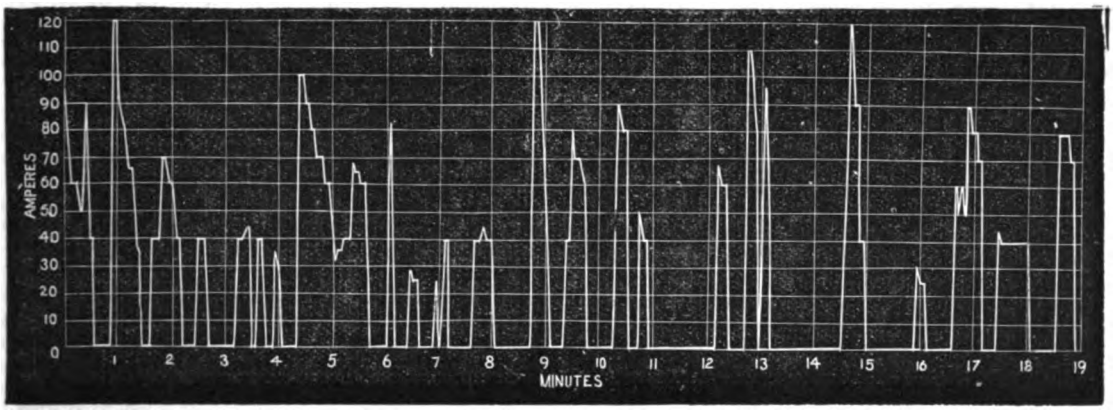

Fig. 3.

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a distance of about seven miles. Every corner on this diagram represents a movement of the switch by the driver.

The switch was constructed to throw the various distinct coils on the field-magnets of the motor into parallel or in series, or into several intermediate steps, and these steps can be readily detected on the sharply defined junctions of the lines showing amperes. The average current consumed throughout this round trip, down town and back to the depôt, amounted to 31 amperes. The weather was dry, windy, and the road very dusty. Allowing for this, as well as the frequent stoppages and slowing down in order to keep pace with the horse cars on the same line, it appeared that there must have been some waste of energy. The diagram shows that there was a continuous effort of getting up great speed at one moment and slowing down the next. It shows that the driver was somewhat nervous and inexperienced to driving in the public streets, hence the frequent alternate use of high currents and brake. The gradients on this road are not very severe, the heaviest is about 4 per cent., and several of 2 and 3 per cent. Calculating as before, and allowing the same efficiency, we should get an average tractive force of 39lb. per ton. The car in this case carried 23 passengers one way, and 30 on the return journey, giving a mean load of 7 tons.

Numerous journeys were made through the city with this car, and some days after the above event I took again careful readings; the driver was more experienced, less nervous, never used the utmost electrical power at his disposal, and the average current during two round trips came to only 23·11 amperes,—25 per cent. less than formerly, under similar conditions of load, speed and weather. Although the average height of the peaks was less in this case, the number of them was nearly the same, and the gaps representing periods when no current was used gave, on being added up, 45 per cent. of the total. Thus for nearly half the time the car was running by momentum alone. It must be remembered that every few hundred yards there is a street crossing those we ran on, and all these streets have their tramways, so that for common safety it was necessary to slacken down at each square or block of buildings, even when other traffic and passengers did not impede our progress. These diagrams teach us two important lessons; one is, that a skilful driver can economise energy to a large extent; the other, that proper appliances for regulating the power within a wide range are a distinct advantage.

After a good shower of rain the tram rails assume a tolerably clean appearance; the mud is then easily squeezed out by the flanges of the car wheels; thus I have observed that during or immediately after a rainfall, the energy necessary for propelling a vehicle is considerably less than in dry weather. There is a positive saving of power amounting to from 15 to 50 per cent. with clean wet rails. By careful observations we were enabled to record the effect of various comparatively small obstacles on the rails, the ammeter showed the minutest variations in tractive force; it is far more reliable than a dynamometer, since it has neither friction nor momentum.

Snow is the greatest enemy of tramways, it offers the greatest resistance to traction. Anticipating snow storms, which occur rather frequently in some parts of the States, we fitted the experimental car with a snow plough and wire brushes. The plough shears were supported by a balanced frame underneath the front platform of the car. These shears could be raised and lowered by foot pressure. Behind the plough shears, and just ahead of the front wheels of the car, were brushes made of steel wire, and these were kept scraping over the rails by their own weight. The plough served the purpose of removing the bulk of the snow, and the brushes swept the rails and grooves clean in front of the wheel flanges. One day when it snowed very hard, and when the rails were covered about a quarter of an inch deep, we ran the car out upon the experimental track, using in the first instance merely the wire brushes and a little sand on the steepest gradient. It took 2min. and 8sec. to run once round the track, which was soon cleared of snow, taking a mean current of 50 amperes. Snow fell hard all the time, yet it required only 35 minutes to make 20 successive trips, with an average of 30 amperes. In the course of four hours the snow was nearly two inches deep, when the car was again started. The brushes alone were of no avail, and the snow plough had to be applied. The first journey was made in 2min. 20sec., but with the enormous expenditure of 80 amperes; each succeeding trip, however, took less time and energy, until it reached nearly to its normal value corresponding to clean rails. This would show that with proper appliances, and with cars rapidly succeeding each other, the track can be kept clear; but the accumulation of much snow in the first instance occasions a fearful demand of energy, and without plough and brushes the snow is compressed by the wheels and renders progress almost impossible.

Recent tests made by a commission on the Frankfurt-Offenbach Electric Tramway, which has been in constant operation for six years, gave the following results:—Two cars, one of which contained the motor, the other an ordinary car attached to it were taken over the line. The motor car weighed 4 tons, the ordinary car 2 tons, and 20 passengers 1½ tons, giving a total of 7½ tons. Measurements with an amperemeter were made every 5 seconds. The electromotive force varied between 240 and 300 volts. At starting the current used was 80 to 100 amperes, which fell to 40 in 10 seconds, and the mean current on the level road at 8 miles an hour fluctuated between 15 and 25 amperes. On a gradient of 2·85 per cent. 55 to 60 amperes were recorded, and the mean current over a distance of one mile occupying seven minutes was found to be 21·48 amperes, and this included four stoppages. The highest amount of energy recorded at any moment, when starting, was 21,700 watts.

Dr. Louis Bell, in an interesting Paper published a few months ago, gave the results of his experiments on the La Fayette Road (Ind.), from which I take the following instructive figures. Experimental runs were made on a level road with a car and passengers weighing together 8,200lbs.

Miles per hour.	Volts.	Amperes.	Electrical H.-P.
7·5	404	9·5	5·15
9·3	416	10·4	5·79
9·1	393	10·7	5·40
10·9	434	16·1	9·35
12·4	433	15·4	8·95

Another test on a gradient of 6·58 per cent. rise, one-tenth of a mile in length, gave the following results:—

Miles per hour.	Volts.	Amperes.	Electrical H.-P.
2·73	347	27·2	12·65
4·20	403	27·4	13·47
9·30	409	31·3	17·14
6·20	365	32·4	15·85

These results are remarkable when compared with those on the level road; considering the steep gradient, one would have expected a much larger consumption of energy at the necessarily low motor speed. On the other hand, the tractive force on the level road appears to be abnormally high at all speeds when the motor efficiency should be at its very best.

More recently Mr. O. T. Crosby published some interesting data concerning three American tramways which, like those of La Fayette, were worked by overhead conductors. The average expenditure of energy on one car on each of the following lines was:—

—	Watts.	Electrical H.-P.	Load.	Average speed.
Richmond	4,883	6·5	8,500	6 miles.
Cleveland	4,986	6·6	9,500	9 „
Scranton	5,587	7·4	9,500	5·7 „

The maximum gradients were given to be at Richmond 9 per cent.; at Cleveland "very slight;" and at Scranton 7 per cent., involving maximum expenditure of power of 25·6 horse-power, 15 horse-power, and 19·2 horse-power (electrical measurements on cars) respectively.

Dr. E. Hopkinson ascertained the mean tractive force on the Bessbrook-Newry Tramway, and he showed that it amounted to 28·9, 27·4, and 37·1lb. per ton of gross load hauled during three journeys. The increase in the third journey is due to the mean speed having been nearly doubled. The gradients are not severe in this case, but continuous in one direction.

From numerous sources at our disposal we find that the mean tractive force may be anything from 30 to 50lb. per ton, and that it is seldom, if ever, below 20lb. on level roads, excepting under very favourable circumstances.

All these figures point to the fact that the mechanical resistances on existing tramways are very great, and that even a slight reduction at a comparatively small cost would bring about a considerable saving in traction expenses. By reducing these resistances we not only save power with existing appliances, but by virtue of a smaller demand of tractive force we are enabled to utilise lighter motors, lighter gearing, lighter storage batteries, which, in their turn, again require less for their own propulsion until a practical limit is reached.

Assuming, *à priori*, high efficiency in electric motors and gearing, improvements as regards mechanical resistance on tramways may be looked for, and, I hope, attempted in the following points:—

1. Solid, well-fixed, parallel rails.

2. Perfect cylindrical wheels, with thin flanges, or some of them without flanges.

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3. Clean rails. The grooves may be swept and watered several times a day by a vehicle especially fitted for this purpose.

4. Sufficient flexibility in axle boxes to allow of free movement in curves.

5. A reasonable number of graduations in the motive power, regulated by a switch.

6. Skilful driving, which should occasionally be proved by careful tests and power curves.

7. Automatic sand boxes on steep gradients where the natural adhesion is insufficient.

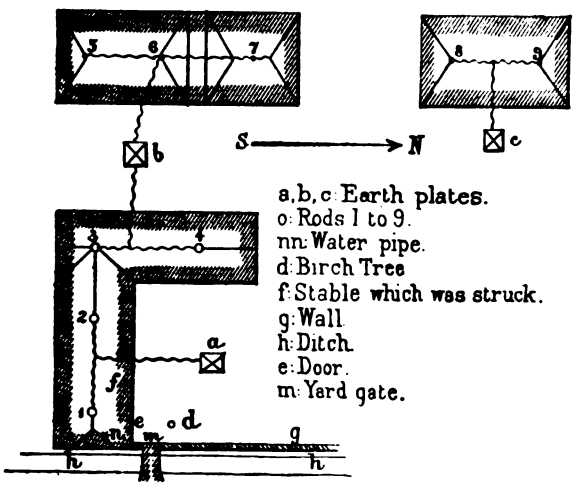
In conclusion, I will repeat that a frequent and judicious use of the ammeter on electric cars will amply repay you for the trouble; it will be the means of great improvements, in the same manner as the indicator diagram enabled us to study the nature of steam engines, and which has been the most direct means of effecting great economy in working.

A REMARKABLE FLASH OF LIGHTNING.*

BY W. KOHLRAUSCH.

On May 15th last I was asked to inspect a stable on the farm of Mr. C. Jagau, near Hanover. On May 8th it had been struck by lightning, which set it on fire and killed a horse which was in it, and this, although the building had four conductors, in the immediate neighbourhood of one of which the lightning struck.

The accompanying illustration shows the positions of the buildings and the conductors. To the east lies the yard, which seems to be quite unoccupied. To the south also there are no buildings within the distance of 100m. It was at the request of Mr. Rudolf Siemsen, who had erected the conductors, that I went to see the place. The iron rods are 4m. high and the 12-strand copper conductors have a cross section of 0·06in. The earth-plates



are 100 by 50 c.m.; those at *a* and *b* hang right under water in two wells; that at *c* is buried 1·5 m. deep in the ground. From the gilded tips of the rods down to the earth-plates, all joints were properly soldered. It might have been well to connect rods 2 and 3 along the roof, but with that exception no fault could be found with the arrangements. Those in the house had no idea that the stable had been struck until, shortly after, they saw smoke coming from the roof, and found that some loose hay lying in the loft was burning, which was easily extinguished; but it was found that a horse was lying dead just within the door. Distinct traces of the flash, in the form of numerous small splinterings, could be seen on the first two beams going to the north-west, under the ceiling of the stable behind the door *e*. Wood was splintered both on the inner and outer sides of the door itself, and here and there its nails and bars were melted at the ends and angles. The yard gate was also splintered. Finally, on the birch-tree *d*, at about 1·7m. from the ground, we found two burns, which were undoubtedly fresh, and which had gone through the bark to the better conducting interior of the tree. The most careful search has not brought to light any other traces of the lightning's course. We took down the conductor 1, but even with a magnifying glass could find no traces of its being touched by lightning. Rod 2 we examined through a telescope with the same result. The common conductor of rods 1 and 2 goes to earth at the well *a*. The water was about 1·5m. below the ground. The well is built in sandstone, and is about 3·5m. deep. The earth-plate *a* was quite under water.

Earths *a*, *b*, *c* were 10 ohms, 11 ohms, and 32 ohms respectively. There is thus nothing much to be said against the arrangement of the conductors. It would have been better had the resistances of the earths been smaller, and had rods 2 and 3 been connected; but I think one can hardly say that the buildings were insufficiently protected, and I can find no definite reason for the fact that the lightning injured them; and, moreover, injured them at a spot certainly not beyond the commonly supposed protective distance of the rod, and which was nowhere more than 5m. from either end of the rod. In this region the ironstone, which lies generally about a metre below the surface, in various sized beds, has a great deal to do with determining the course of a flash of lightning; but, on digging in the stable, near the birch, and round the neighbourhood where the lightning struck, we came to the water-level at 1·25m. down, but found no ironstone. The nearest we found was a small bed in the field, towards the east and about 25m. from the stable. The field lies about 0·8m., and the water in the ditch *h* about 1·3m. lower than the yard. In the stable or beneath it, was no amount of metal worth mentioning. No farm implements were kept there; the stable was empty, save for the horse, which happened to have been put there temporarily.

The following explanation is possible:—The lightning struck the highest point in the neighbourhood, the birch *d*, passed through the twigs at *n*, which touched the roof of the building, and also through the tree, coming out lower down the tree, from whence it injured the yard gate *m*. All visible traces left by the flash fit in with this theory, for all the injuries to the building itself are just under the twigs *n*.

* From the *Elektrotechnische Zeitschrift*.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, May 9th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Colour Vision and Colour Blindness." By R. BRUDENELL CARTER, F.R.C.S.

TUESDAY, May 13th.

INSTITUTE OF MARINE ENGINEERS.

7:30 p.m. Paper to be read: "Corrosion of Iron and Steel. By D. PHILLIPS.

INSTITUTION OF CIVIL ENGINEERS.

8 .m. Ordinary Meeting. Paper to be further discussed: "The Screw-Propeller." By SYD. W. BARNABY, M.Inst.C.E. Paper to be read, time permitting: "The Keswick Water-Power Electric Light Station." By W. P. J. FAWCUS and E. W. COWAN, Assoc.MM. Inst. C.E.

SOCIETY OF ARTS.

8 p.m. Applied Art Section. "The Use of Alloys in Art Metal-Work." By Prof. W. C. ROBERTS-AUSTEN, F.R.S.

WEDNESDAY, May 14th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Lecture: "Prof. Elihu Thomson's Electro-magnetic Induction Experiments." By Dr. J. A. FLEMING, M.A.

ROYAL SOCIETY.

9 p.m. Conversazione.

THURSDAY, May 15th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Flame and Explosives." By Prof. DEWAR, F.R.S.

CHEMICAL SOCIETY.

8 p.m. Papers to be read: "On Diethylphosphorous Acid." By Prof. THORPE, F.R.S., and Mr. BARKER NORTH; "The Ten Isomeric Dichloronaphthalenes," and "The Action of Chlorine on Naphthalene and Naphthalene Derivatives," by Prof. ARMSTRONG and Mr. W. P. WYNNE; "A Third Naphthaquinone," by Prof. MELDOLA and Mr. FRANK HUGHES.

FRIDAY, May 16th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: "On Huygen's Gearing in Illustration of Electric Induction." By Lord RAYLEIGH, F.R.S. "Dr. R. König's Researches on the Physical Basis of Music." By Prof. SILVANUS THOMPSON, D.Sc.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Photographic Image." By Professor RAPHAEL MELDOLA, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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EFFICIENCY OF GLOW LAMPS.

Among the many subjects which the progress of electrical engineering has brought into prominence of late years is the question of the efficiency of incandescent lamps, the importance of which is sufficient to merit fuller attention than it has yet received. Although; no doubt, a very large number of investigations have been made, the whole question is not nearly so clearly understood as is, for example, the theory of dynamo design. This is largely due to the fact that experiments on lamps, to be of any great practical value, must not only be spread over a long period of time, but must also be made on a large number of lamps so as to secure good average results. Other subjects can be more or less satisfactorily dealt with by individual experiments; but the only way this question can be properly attacked is by means of the method of averages. As a matter of fact, the greater number of experiments hitherto performed have been rather of an individual than of a collective nature, and are thus open to objection. It is scarcely possible to expect companies to devote a large amount of trouble and time to a question of this kind; but it is a great and promising field for a private investigator who is fortunate enough to have at his disposal the time and means needed to

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carry out the work. If such a one were to run a large number of lamps of the same type at various voltages, keeping careful time-records of the individual life and candle-power of the same during the whole time that the lamps lasted, he would secure a large amount of valuable information, which is much needed and which would be eagerly welcomed by electrical firms. The causes of individual variations is, again, a subject of which little is publicly known, but which would richly repay separate investigation. Among such causes are the state of the vacuum, the nature of the surface and the form of the filament, all of which considerably influence the radiation coefficient; not to mention more obscure points, such as the conduction of heat down the terminal wires.

But apart from the difficulty which arises from the existence of individual peculiarities, there are others arising from the nature of the investigation itself. The very definition of lamp efficiency is obscure, since the circumstances under which efficiency is to be measured are by no means generally agreed upon. No doubt the most scientific way to measure the efficiency would be to take the ratio of the light energy given off to the electrical energy supplied; but this is quite impracticable, owing to the impossibility of measuring the intensities of the different component rays in the emitted light and afterwards summing the whole. What is usually taken to indicate the efficiency is the number of watts required to produce each candle-power of light in the lamp; and, as this is practically what is required to be known, we cannot at present do better than continue the use of the term in this sense. However, after the adoption of this as the meaning of the term "efficiency of a lamp," we are met by other difficulties, for it is well known to be possible to get almost any efficiency, even as high as one-fifth of a watt per candle, provided shortening the life of the lamp is no consideration. The efficiency of a lamp, instead of being constant, may be almost anything, depending on the life. Without a vast amount of preliminary investigation it is impossible to test lamps with currents such as they would stand on the average for equal intervals of time; so that we may say that it is impracticable to test lamps under the conditions of equal life. The alternative, recently suggested in our correspondence columns, of testing the life of lamps under conditions of constant efficiency is more practicable and worthy of attention, although open to some objections. While, however, it is impossible to speak generally of the maximum efficiency of any particular lamp, it is quite possible to speak of the maximum efficiency of a particular type of lamp when we are given the cost of power and lamps as well as the average life. Curiously enough, the maximum efficiency in every case arises when the cost of lamp renewals is about 15 per cent. of the total operating expenses of the plant. It should be carefully noted that in this case it is not the goodness of the lamp which altogether determines the efficiency under these conditions, for local questions are also of great importance.

The foregoing considerations sufficiently account for the usual plan of testing the lamp efficiency at the voltage recommended by the makers, and of making separate determinations of candle-power and life at that voltage. Perhaps the most complete set of tests made, since the celebrated ones of the Franklin Institute, are some by Mr. W. L. PUFFER, which recently appeared in the *Electrical Engineer* of New York. Although very complete, and made on several types of lamp, they are not in any way average results, but refer solely to the individual lamps employed by his pupils in the tests. The lamps experimented on were of fairly recent manufacture and bought in the open market. The standard used was a carefully adjusted Methven screen, and by means of an ingenious holder each lamp could be turned or raised to any desired degree. Five characteristic curves are given for each lamp, and, by an admirable method of plotting, all possible information is given in a way so that the capabilities and peculiarities of each lamp can be seen at a glance. The results are of interest as showing how near the rated value of a lamp is to its true value, and also how largely the efficiency of good lamps may vary even when of the same type. Although in about half the cases the mean horizontal candle-power comes out above the rated value, in every case the mean spherical candle-power is considerably below, and only represents about 90 per cent. of the rated value. The efficiencies vary largely, from 3 to 6 watts per candle; and although from the absence of any data with regard to the life of the various lamps it is impossible to compare the results, it is interesting to notice that such large variations are possible with lamps worked at rated voltage, and this fact alone shows that the manufacturer of glow lamps is far from equalling the dynamo maker in being able to turn out a large number of articles which are all practically identical. Mr. PUFFER points out the importance of such experiments in connection with the rated power of lamps. The fact that the mean horizontal and mean spherical candle-power may differ so greatly not only shows up another difficulty in measurement, but also renders it desirable to define more explicitly than has hitherto been done the exact meaning of the candle-power of a lamp. Electrical progress has been already so much injured by lawsuits that no precaution should be neglected by means of which future litigation may be lessened. It is to be hoped that some capable investigator will take up the entire question, so as to procure a more complete set of experimental data than any we are in possession of at the present time.

THE BOARD OF TRADE AND ELECTRIC LIGHTING COMPANIES.

The President of the Board of Trade, Sir Michael Hicks-Beach, M.P., received on Friday last a deputation from electric lighting companies respecting the clause in the Model Provisional Order giving local authorities the power of absolute transfer of Provisional Orders under the Electric Lighting Acts.

Sir J. PULESTON, M.P., in introducing the deputation, said that they came there to the Board of Trade because they were sure that the Board desired to facilitate rather than to retard the progress of electric lighting. He might say at once that he had no personal interest in this matter, but he was inclined to take a general interest in it since the first Parliamentary Committee of 1882, of which he was a member, and he recollected that the question of delegation was one on which they stated their views very strongly. Under this Clause 60 of the Model Provisional Order practically the local authorities would be able, if they felt so disposed, to sit upon the Provisional Order, for the great interest local authorities invariably had in gas companies would considerably influence them in the direction. The Act of 1888 provided for the longer tenure of 42 years, but he considered if the powers proposed by this transfer clause were conceded to local authorities, they would be in a position to reduce the time again to 21 years.

Mr. J. FLETCHER MOULTON, Q.C., said that Sir Michael would probably remember the Select Committee of 1882 before which the Electric Lighting Bill came, and the whole question of the transferring of Provisional Orders or Licences was considered very carefully; and he thought that the dominant feeling in the Committee was that if their rights were granted by Provisional Orders or Licences they should not be in the nature of concessions in which traffic could take place; that the power of supplying the electric light in a district was consistent with public duty, and was not a matter which should be handed from one person to another without the direct control of Parliament. He remembered that it was most distinctly stated by the representative of the Board of Trade, and he could certainly say it came before the whole of the Committee, that local authorities, if they came forward to ask for power to distribute electricity, their intentions must be *bonâ fide*, there must be no "dog in the manger" policy; and he might also say, it should be their intention to immediately put it into effect. He did not for one moment mean to say that the views of the local authority should be disregarded; but it was never intended that the local authority should necessarily stop a company from supplying the public with the electric light, and, further, it was not intended that the local authority should have powers if they did

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not mean to do the work. In 1888 another Committee was appointed by Parliament to consider the question of electric lighting, as the thing had practically broken down because the Electric Lighting Act allowed so short a period as 21 years in which the Company would have to establish its works, get customers, make its profits, and provide for depreciation. 21 years was too short, and the Act of 1888 dealing with this put down 42, which he thought a very reasonable number of years; but, at the same time, a clause was put in giving greater statutory weight to the position of the local authority. Otherwise he thought the Act of 1882 practically remained unchanged. Now, last year, he believed for the first time, at the application of one local authority, a clause was put in the Order giving that local authority the power of transfer. That was, he believed, in the case of the Swansea Electric Lighting. The question of this transfer clause being put into the Orders has been before the companies, and he thought the Board of Trade at the commencement of the year rather favoured its not being inserted; but there had been a discussion on the subject with the municipal authorities, and he understood it was going to be inserted in all Provisional Orders granted to local authorities. In his opinion, this transfer clause was contrary to the principal Act, which overrides all Provisional Orders. It was not within the power of a Provisional Order that it should be allowed to be transferred, without going to Parliament, from a local authority to a company, and he submitted that it would be very detrimental to the interest of the public if this clause were inserted.

The PRESIDENT: The Act already enables the Board of Trade to sanction transfers.

Mr. MOULTON said that this was quite different to the proposed clause; for whereas one provided for the transfer of certain portions of the Order, the other gave the power of bodily transferring the whole of the Provisional Order. Mr. Moulton then read Clause 4, which he said provided that no Provisional Order could authorise the supply of electricity unless notice had been given of such Provisional Order. But under the new clause it was different. The local authority might give the notice, and might obtain the Order. The local authority would be able to transfer the Order to a Company, and that Provisional Order would authorise that Company to distribute electricity, although the Company had not given any notice. If this was to be the case, a body of middlemen would be created, and they would decide—not the Board of Trade, not Parliament—who were to be the undertakers. Mr. Moulton said, of course the granting of a Provisional Order to local authorities was a step which Parliament regarded with very great favour; but he submitted that it was intended that powers for distributing electricity should not get into the hands of any company without this notice to the public, and that the Provisional Order was intended to mention the persons who were to be the people to have the direct supply.

The PRESIDENT stated that, so far as the Board of Trade were concerned, companies would get as much protection as before, but he supposed they were afraid of losing the protection of Parliament.

Mr. MOULTON said they would lose the protection of Parliament, and he also believed in a measure they would lose the protection of the Board of Trade. They had heard of grave abuses by municipal corporations in other countries, but he hoped they would not have them in his country; still he submitted it was necessary to consider this. He submitted that the clause not only went beyond what was meant by the Act, but it was organising a mode of dealings in concessions.

Mr. HENRY KIMBER, M.P., referring to the fact that the President had stated that they had the power of revoking the Order after the lapse of two years when nothing was done under same, said that in the case of Brighton the Corporation had had the Order for seven years, and had only just recently intimated the intention of undertaking the responsibilities of the Order. He was quite sure that in some cases if the public had an opportunity of coming to the Board of Trade the position of local authorities who had obtained powers under the Electric Lighting Act would be very different.

The PRESIDENT said that the local authorities were the elected representatives of the public. He did not look upon local authorities in the same light as private companies.

Mr. B. R. W. WILLIAMS said that Sir Michael would probably remember that last year he had an interview with him (Sir Michael), and he pointed out that in 1883 a great number of Provisional Orders were granted to Corporations and also to private companies, and whereas in every case of the latter the Orders had been revoked, not one of the Orders of local authorities was revoked. He (Mr. Williams) pointed out the injustice of this, and in reply Sir Michael said that he looked upon local authorities in a totally different light to supply companies.

The PRESIDENT: You are carrying my words rather farther than I intended. I did not say I would not revoke any Order of local authorities.

Sir JOHN PULESTON remarked that the real point was, they were desirous of promoting the science of electric lighting, and did not wish to see its progress impeded.

The PRESIDENT: I do not think it is the business of the Board of Trade to force the electric light on any town.

Sir J. PULESTON: No, but to facilitate it.

The PRESIDENT. Ah! the two words have very much the same meaning in this sense. If the local authority used the powers given them to keep the electric light out of its town I should, of course, not allow that.

Mr. KIMBER: Then I hope you will hear anybody who can adduce instances of these cases.

The PRESIDENT: Yes, certainly.

Mr. KIMBER: But you say, Sir, that you cannot have the public here.

The PRESIDENT: I say it is not within my right to interfere with the public, because they have their own elected representatives.

Mr. MOULTON was proceeding to refer the question of spending the ratepayers' money, when

The PRESIDENT (interrupting) said: The question of obtaining the money is another point. The argument laid before me is that the local authority will not spend more; they will do nothing directly or indirectly in electric lighting. I think that you had better submit to me in writing your objections to this clause. Mr. Moulton has stated them very ably, and I should like to have them before me. I should particularly like to have your views as to the question of the terms. It could be argued that it is one thing for local authorities to do the work, to establish works of their own, and then let them from time to time; but it is another thing to give over the concession for 21 years.

The deputation then thanked the President of the Board of Trade, and withdrew.

CENTRAL LONDON RAILWAY BILL.

HOUSE OF COMMONS.—FRIDAY, May 2nd.

Mr. PEMBER, Q.C., having stated that an arrangement had been come to with the Gas Light and Coke Company, by which further opposition on their part would be obviated, Mr. Rigg proceeded to call evidence on behalf of the London, Chatham and Dover Company in opposition to the Bill.

Mr. FORBES, Chairman of the Company, said in his opinion the line must turn out a financial failure, and at the same time the Central London Company would be occupying ground which some one else might want for the construction of an ordinary underground railway worked by steam. His Company would be prepared to construct such a line, supposing there were the slightest probability of their obtaining the consent of the frontages.

Mr. BINNIE, Engineer-in-Chief to the County Council, and Mr. S. HARRISON, Chairman of the Parliamentary Committee, gave evidence as to the protection which would be required to the sewers; and Sir JOSEPH BAZALGETTE said he considered that the scheme, if carried out, would greatly interfere with the sewers.

MONDAY, May 5th.

Mr. LITTLER, Q.C., addressed the Committee on behalf of the Corporation of the City of London in opposition to the scheme. He said his clients were only too anxious to see any increased means of locomotion adopted which would tend to the comfort and convenience of the travelling public; but they objected to the ground being occupied by a scheme which might or might not be a success. In the present state of engineering experience of the means of locomotion proposed, the Committee would not be justified in authorising such a scheme as the present for some year or two—at any rate, until experts had been to America and reported exhaustively upon the working of the electrical lines there. Supposing this line turned out a failure, there would be a tube left in the ground that would be absolutely useless for any purpose whatever.

Mr. BELL, on behalf of the Metropolitan Railway Company, examined by Mr. Littler, said: Such stress had been laid upon the success of the system of working by electricity in America, that he had been there to see it in actual working, and he found nothing but tramways with only one car working at a time. On the Manhattan Railway, which was 25ft. above the ground, experiments had been made with electrical traction at a cost of $100,000, which turned out a failure, and he had seen the electrical engine lying on the rails rusting and useless.

To Mr. Freeman: If any further development of underground traffic were called for within the circle of the metropolis, his Company ought to have the first chance. He would admit that this route contained the plum of the traffic, and the Metropolitan would be very glad to lay down a line along it, if there were the least likelihood of getting the consent of the frontagers. For the last three years a system of working by electricity on the Underground Railway had been under consideration, but the expense attending such a change would have been very large, and at present they were not satisfied that any system of working that had been before them would be satisfactory. When in America he had not seen two cars containing 96 passengers working on a gradient of 1 in 8 by the Thomson-Houston system. If it were the case such a thing could not have been done by an ordinary locomotive.

After some further evidence, Mr. LITTLER addressed the Committee on behalf of the Metropolitan Railway Company in opposition to the Bill, after which the Committee adjourned.

TUESDAY, May 6th

Mr. PEMBER, Q.C., replied on behalf of the promoters. He said there were originally 37 petitions against the Bill, but now he had only some 19 or 20 petitions to deal with. There were six points which had been urged against the Bill: (1) Engineering risks; (2) Injury to Oxford-street tradesmen; (3) The question of subsoil; (4) The question of the feasibility of electrical traction, and the working expenses incidental to the application of electrical traction; (5) The chances of traffic if the line were once made and put into operation; and lastly, that precious plea for postponement, which had been put forward on behalf of nearly every one of the opponents. With regard to the first point, they had the experience of the construction of the Metropolitan and District Railways, and other railways. With regard to damage caused during construction, it had been stated by Sir Benjamin Baker and others that the total amount of damage caused during the construction of the City and Southwark Railway would be covered by a sum of £10,000. It was proposed to construct the line throughout in the London clay; and in 57 borings which had been made in the four miles of line, they had found the London clay in every case, and even if it should turn out that

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there was a pocket of sand or gravel, they would be able to minimise any danger by working with shields and the compressed air system. The learned counsel contended that some underground scheme was absolutely necessary; and he asked the Committee, after hearing the evidence which had been given by such eminent engineers as Sir John Fowler, Sir Benjamin Baker, and Mr. Greathead, to sanction an electric scheme of the kind proposed as being preferable to an ordinary railway worked by steam. In order to pay a fair interest upon working expenses it had been calculated that they would require to carry 28,000,000 passengers; and remembering that the Metropolitan and the Metropolitan District carried 117,000,000, it was not a very violent assumption to expect that the proposed line would carry one-fourth or less than one-fourth of that number. On the proposed line they only looked for an average fare of 2d., as against the present average omnibus fare of 1·66d., and that, it must be remembered, was earned from passengers whose average journey was only a mile and a-half. When judged by the ordinary standard of Parliamentary proof by evidence in favour of such measures as this, the probabilities of ultimate success were unusually high.

The Committee then deliberated in private for some time; and on the re-admission of the parties,

The CHAIRMAN (Mr. Walter James) gave the following decision:—The Committee find that the preamble of the Bill has been proved, subject to the promoters satisfying them upon the following points:—They consider that a proviso should be inserted at the end of Clause 35 of the Bill similar to that which was inserted in the Midland Railway (Additional Powers) Act, 1881, providing that nothing shall relieve the Company from liability to pay compensation under Section 68 of the Lands Clauses Consolidation Act. The Committee also consider that stringent clauses should be inserted affording every opportunity to the engineers of the Corporation of the City and of the County Council during the progress of those works for inspecting them, lest any possible damage should be done to the sewers, mains, or other public works under the streets, and that the owners of property and all the local bodies should have full opportunity of watching their own interests. The Committee also consider that the margin in the financial proposal of the Company is somewhat too large, and that is a point they will have to consider in connection with the estimated capital of the Company. The remaining point is, that they consider that, until the City and Southwark Subway has been opened, and has been used by the travelling public for a certain time, no prospectus of the Central London Railway should be issued, and no capital should be raised.

Mr. SAUNDERS, Q.C., on behalf of the promoters, gave an undertaking to bring up clauses carrying out the decision of the Committee, and to supply all the opponents with copies.

The Committee then adjourned until next Tuesday for the discussion of clauses.

THE RAILWAY RATES INQUIRY.

The Board of Trade inquiry as to the tables for the classification of merchandise prepared by the railway companies in compliance with the provisions of the Railway and Canal Traffic Act of 1888, has been continued during the present week.

Upon the article "wire, cotton-covered, in casks, hampers, cases and canvas-covered coils,"

Mr. TROTTER, for the Electrical Section of the Chamber of Commerce, said there seemed to be some misconception as to the nature of this article and its value. It was objected by the railway companies that it was used for the same apparatus, and was equally if not more valuable than gutta-percha-covered wire, which was in Class 4, and to which the traders had no objection. But cotton-covered wire was essentially a raw material, as far as dynamo makers and manufacturers of electrical machinery and apparatus were concerned. It was a heavy article, and of a value only about 23 to 25 per cent. more than that of copper wire. It was not liable to damage, and he had information from various manufacturers saying that 1 per cent. covered all the damage they experienced. The value of the gutta-percha wire varied from £200 to £300 per ton, and it was considerably liable to damage. A very small amount of damage to gutta-percha wire would simply ruin it. He did not press for any alteration in this respect; but cotton cooper wire went in canvas-covered coils and casks, and frequently travelled in wooden drums, which were sent from the coverer to the manufacturer, and then it was practically unable to be injured It was easily loaded in quantities. It was heavy, and was well packed, and it went directly from the wire coverer to the manufacturers of electrical apparatus.

Lord BALFOUR of BURLEIGH remarked that Mr. Trotter was under a misapprehension as to the class in which these articles now appeared. The railway companies said that "the second-class entry in the clearing-house classification to which presumably the objectors allude does not refer to wire for telegraph or electrical purposes, but for millinery and other similar purposes.' After that explanation would the traders be satisfied with the clearing-house classification?

Mr. TROTTER said he had noticed the observation of the railway companies, but he did not see any further entry in the clearing-house classification than copper-covered wire for telegraph or electrical purposes. He was not aware that they intended wire used for millinery and similar purposes. He had used many tons of it.

Mr. WILKINSON (Great Western), in replying to a question by the Court, stated that these goods at the present time were in the third class, under the entry "wire, copper, or brass." The railway companies thought that one class higher was reasonable for this article. They were themselves very large consumers of it, and were fully acquainted with its value, which was very great. Ordinary copper wire was worth £120 per ton; this was worth £200. The railway companies were prepared to leave the matter in this way. Common wire was in Class 3, and one class more was a reasonable thing for wire covered in this way. Their present powers were, of course, the highest they had. It was a bulky article, and was liable to damage. If a cask or case got wet, the company would be called upon to pay.

Lord BALFOUR OF BURLEIGH: Is this article all copper wire?

Mr. TROTTER: Entirely copper.

Lord BALFOUR OF BURLEIGH: Then it ought to be so described.

Mr. TROTTER said the traders were quite prepared to describe it in that way, but there were some quantities of German silver and other wire used. They were quite prepared to distinguish the copper wire. The increase in value for covering the wire was about £18 per ton; the bulk was not more considerable—the difference was unmeasurable. Cotton-covered copper wire was worth about £72 per ton at the present moment.

LEGAL INTELLIGENCE.

Chamberlain and Another v. The Cadogan Electric Light Company.

In the Queen's Bench Division, last week, before Baron Huddleston and Mr. Justice Grantham, this case came on for hearing. Mr. Hugo Young appeared for the plaintiffs, and Mr. Ruegg represented the defendant Company.

This was an appeal on the part of the defendants from the decision of the County Court judge at Birmingham, particulars of which will be found in *The Electrician* of March 14, p. 482.

Mr. RUEGG said that the defendants did not now appeal as to the judgment on the counter-claim, and only contested the County Court judge's decision as to the claim. In substance the judge found in favour of the defendants, on the fact that the meters supplied to them by the plaintiffs were not reasonably adapted for the purpose of registering electricity; but he held that in law, upon the correspondence, there was no express warranty, and that, under the circumstances of the case, the usual implied warranty that the manufacturer who manufactured an article, and supplied it for a given purpose, warranted that it was reasonably fit for that purpose, did not apply. His (Mr. Ruegg's) contention was that the County Court judge was wrong on both grounds. He said there was, in the correspondence in the case, an express warranty that the meters were fit for the purpose for which they were supplied, and that there was the usual implied warranty which attached to manufacturers who supplied an article, knowing for what purpose it was to be used.

Mr. HUGO YOUNG, for the plaintiff, in support of the decision of the learned judge at Birmingham, said his Honour had found, as a fact, that a meter to measure electricity was a new article in the trade; and it was known to all electricians that, up to the present time, there was no such thing known as a perfect meter to do this work. Therefore, what the judge had found was, that the circular issued by the plaintiffs was merely a trade circular describing a general class of article, and intended to convey what the meters might be expected to do under proper circumstances and conditions. But the judge had said that the circulars were by no means a warranty of what the meters would do on all occasions.

Baron HUDDLESTON, in giving judgment, said the real point which the Court had to consider was whether the County Court judge was right in point of law in saying he could not connect the correspondence between the parties in March with the sale at a subsequent date. His Honour seemed to be of opinion if he could do that he would have found a verdict against the plaintiffs. He thought the correspondence could be imported into the contract, and that being so there was no doubt that there was an express warranty, because plaintiffs, in one of their letters in answer to defendants, said, "If you are in want of a reliable meter we can assure you you need not look any further, as you will find ours both reliable and practical." Judgment would therefore be entered for the defendants, and the appeal allowed with costs.—Mr. Justice Grantham concurred.—Leave to appeal was refused.

Re the International Cable Company.

A petition presented by Mr. Bolton for the winding up of this Company was heard on Saturday last before Mr. Justice Stirling, in the Chancery Division of the High Court of Justice.

Mr. Buckley, Q.C. (with him Mr. John Chester), for the Company, asked for leave to use further evidence on the petition which had just been received from Paris from Mr. Dijon; but

Mr Hastings, Q.C. (with him Mr. G. Woods), for the petitioner, objected to its reception on the ground that the evidence had been filed after the petition was opened on the previous Saturday.

His Lordship declined to allow the evidence to be used.

Mr. HASTINGS said this was a petition by a contributory, asking that the Company might be wound up, on the ground that the substratum of the Company had gone. The Company was formed in December, 1885, with a nominal capital of £1,000,000 in £10 shares, to lay a cable between Portugal and America, but up to the present it had done nothing but lay the shore end at one place, and to obtain from the Government a contract for laying a cable between Halifax and Bermuda, which had been handed over to the Halifax and Bermuda Company, in which this Company had a large interest. In November, 1886, the Company issued its prospectus. Among other applicants for shares was the petitioner, who now held 1,000

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shares, upon which he had paid £1,000. Nothing like the requisite number of shares had been applied for which the Directors said were necessary to commence operations with. After the allotment in December, 1886, an extension of the Portuguese Government's concession was obtained till June 30, 1888, and it was again extended till June 30, 1889; and the petitioner alleged that it was impossible to obtain any further renewal. The Company did not dispute that the concession had lapsed, but their case, according to the evidence, was that they had hopes of getting it renewed and extended. As the real thing which the shareholders had been invited to join the Company to work, namely, the laying of a cable under a particular concession, could not be carried out, it was perfectly clear that the petitioner was entitled to a winding-up order.

TUESDAY, May 6th.

After a further statement by Mr. GROSVENOR WOODS, who appeared with Mr. GRAHAM HASTINGS, Q.C., for the petitioner.

Mr. WARRINGTON, on behalf of seven shareholders holding 3,410 shares, representing £34,100, supported the petition.

Mr. BUCKLEY, Q.C., and Mr. CHESTER appeared for the Company, and for the holders of 5,075 shares, and opposed the petition. Mr. Buckley said the total number of shares issued was 25,914, upon which £69,049 had been paid, and submitted that the Court would not, on behalf of one shareholder, make a winding-up order when the large majority were in favour of going on. He denied altogether that the substratum of the Company had gone, and referred to Clauses *p* and *q* in the memorandum, which gave the Company power to form new companies and take shares therein, and to the fact that the International Company had formed the Halifax and Bermuda Company, and were largely interested in its success; and, as the British Government had granted a concession to the Company, under which they would pay a subsidy of £8,100 a year, it could not be said that the Company had not commenced business. He also denied that the Portuguese concession had lapsed altogether, no decree having been passed putting an end to it, and the Directors had every hope that it would be renewed.

Mr. CHESTER having followed, and cited several authorities bearing on the question of whether the substratum of the Company could be said to have gone,

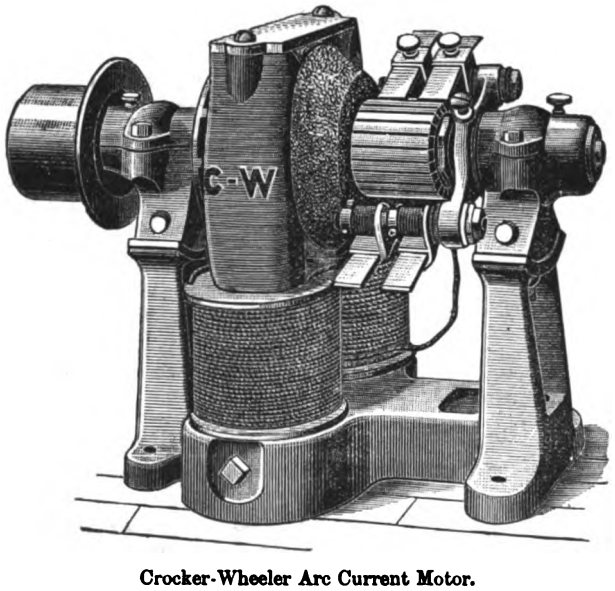
Mr. BAINES, on behalf of 12 shareholders holding 1,178 shares, in respect of which £11,490 had been paid, and for three creditors whose debts amounted to £70, also resisted the petition.

Mr. HASTINGS having replied at some length,

Mr. JUSTICE STIRLING said he would give judgment in a day or two.

THE CROCKER-WHEELER ARC CURRENT MOTOR.

Mr. F. B. Crocker and Mr. S. S. Wheeler, says the *Electrical World*, have produced a self-regulating constant-current motor that overcomes many previously existing obstacles. Heretofore at-



Crocker-Wheeler Arc Current Motor.

tempts have been made to regulate such motors by changing the magnetic strength of the field; but this arrangement is likely to cause the serious defect of sparking at the commutator, and does not admit of instantaneous regulation. This latter is apparent, for an appreciable time must elapse before the change of strength of the magnetism can exert itself, and the machine will "race" before the governor can control it. In the motor under consideration these difficulties are overcome, as the regulation is effected by moving the armature shaft on its bearings in and out of the field, thus instantly increasing or diminishing, proportionate to the load, the amount of torque. By this arrangement is avoided the shifting of the line of commutation, and the result is the entire absence of sparking. The moving of the armature shaft, which is controlled by a mechanical device, also distributes evenly the wear on both the bearings and the commutator. The electrical conditions of the machine are thus undisturbed, so that a continuous current is maintained throughout the circuit, and the armature may be at rest for any length of time, with the full strength of the current flowing through it, and yet sustain no injury. In running pumps and elevators this property is particularly advantageous, and it is one of the essentials in which this motor differs from the constant potential motor, which is destroyed if the full pressure of the current meets the armature for even a short period while the armature is at rest.

The speed of the motor will not change with a varying current, even though the range be from 10 to 5 amperes. The ½ horse-power machine shows a difference of potential of less than 50 volts on a 10-ampere circuit, and the 1 horse-power of less than 100 volts. In small motors the regulation is effected by hand, and in the motors of ½ horse-power and upward by automatic control.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 18, 1890.

A New Vacuum Pump for Incandescent Lamps.—A novel vacuum pump for exhausting incandescent lamps has put in an appearance, suddenly coming to the front after a couple of years of quiet experimenting. Instead of being a mercury pump, it is a modification of the cylinder air pump. The radical improvement, however, consists in the fact that the pump is a compound one, two of the pump cylinders not only doing their share of exhaustion, but keeping a vacuum jacket around the third cylinder. As the difference in pressure between the outside and the inside of this last cylinder becomes very small indeed, there is almost no tendency to leakage in the joints, and a vacuum can be obtained comparing well with that reached by good mercury pumps, and as the pump cylinders are large, the exhaustion goes on more rapidly. During a recent test at Boston a large bank of lamps was completely exhausted, and the current turned on in 23 seconds from the time the pump was started.

A Motor without Field Magnets.—A motor has recently been patented here which is worthy of some study from those persons who are disposed to neglect the magnetic effect of the armature in dynamo-electric machinery. The motor in question has three armatures, and no field-magnets at all. The brushes of these armatures are symmetrically disposed, each pair being distant from each other 60 degrees, with a result that the poles formed in the three armatures control each other so as to cause continuous rotation. An experimental machine using three armatures of the size employed in 6 horse-power motors has been completed, and runs well.

The Edison and Thomson-Houston Companies.—The alleged combination between the Thomson-Houston and Edison interests has proved, as I suggested in a recent letter, to be no more than a quiet agreement not to cut each other's throats in the matter of prices quite as much as they have been heretofore doing. It is no easy matter to unite two gigantic corporations, and their relations can never be the most harmonious; but there has been such deadly competition in electrical matters recently that the companies are glad enough to call a truce without entering into any formal combination.

NEW YORK, *April* 24, 1890.

The New York Street Lighting.—There is mingled indignation and amusement among electric light companies in this city at the threat made by the Gas Commission to abandon electric light and go back to an attempt at street lighting with gas. Owing to the great trouble in getting proper subway accommodations, and the increased expense of operating where subway construction is used, the electric lighting companies, when the propositions were made for the next year's service, raised their price. Last year the contracts were let at a price of about 35 cents per lamp per night. This year, however, all bids made on the city lighting ranged in the vicinity of 40 cents, 39 cents being perhaps a fair average. At the present

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price of subways there is very little money in lighting even at this latter figure, and as the companies do not care to light the streets for glory, it is not expected that much lower bids will be obtained. The Gas Commission, however, waxed exceedingly wroth when the bids were opened, and raised a howl of corruption and combination, which has up to the present produced little or no effect. One thing is very certain. The public will not tolerate dark streets after some years of excellent lighting by electricity. As to the electric light companies, up to the present they are minding their business and waiting further developments, with every probability of getting ultimately their own terms.

High-Speed Electric Traction.—High speed electric traction seems to be one of the probabilities of the near future. The Weems Electric Railway Company is transferring the scene of its experiments to a point near New York, and is about to lay down four or five miles of experimental track.[1] This is the system which reached a speed of over two miles a minute in some of the earlier experiments made near Baltimore; and as the engineering and operation of the problem are in skilful hands, and the Company is well backed, it seems likely that the feasibility of extreme high speed will be demonstrated in the near future. What the final results will be, of course, no one can tell at this time; but there is every prospect that we shall be treated to some striking experiments. A rather extraordinary project for reaching the same end is being pushed in Boston by the Portelectric Company, and several miles of experimental track are being laid down there. It will be remembered that this system involves what is almost a continuous solenoid the entire length of the track; and although no experiments on a practical scale have as yet been made, the Company is making a great deal of talk about what it proposes to do; and electricians, most of whom have viewed the project with rather sceptical eyes, are waiting eagerly to see something done. The possibility of reaching enormously high speeds by the use of electricity no one doubts; and for transporting parcels, mails and the like, such systems would be immensely useful; but whether the public would take kindly to speeds approximating that of a mortar shell, remains to be seen. However, 30 miles an hour was denounced as desperately dangerous and well-nigh impossible in the early days of steam railroading, so that it is not impossible that a few years hence we may be as thoroughly reconciled to three miles a minute as we are now to one.

The Westinghouse Electric Railway Company.—It transpires that the new Westinghouse Electric Railroad Company which is about to be formed will not use the alternating system, but, instead, a direct-current system with overhead trolley.

Combination of the Brush and Julien Storage Battery Interests.—A report has come to hand of an approaching combination of the Brush and Julien Storage Battery interests with the Daft Motor system. This would look as if there was to be an attempt to develope storage battery traction.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

May 7, 1890.

An important question is at the present moment occupying the attention of our municipal authorities, viz., how best to light the big shop known as La Belle Jardinière, which is situated in the Rue du Pont-Neuf, 400 metres away from the central lighting station at Les Halles. The proprietors of this shop, being anxious to replace their gas by electricity, approached the town of Paris with a view of obtaining the necessary current from the municipal station. Our municipal authorities were so glad at the prospect of obtaining such a large order, that they immediately decided that this lighting should be undertaken for the sum of 80,000fr. per annum, which is the price now paid for gas. At first it was proposed to employ Ferranti machines for this purpose, which up to the present have not been brought into operation; but those responsible protested against the employment of 2,400-volt machines to carry out the lighting of an installation a few hundred metres distant. The installation at La Belle Jardinière will comprise 2,000 16 candle-power incandescent and 100 5-ampere arc lamps, representing a total of 145 kilo-watts. As each of the Ferranti machines has an output of 2,400 volts of 45 amperes, this installation alone would require one and a-half machines, leaving only about 80 kilo-watts available for all other customers, the third Ferranti machine being kept ready as a reserve. Moreover, as the shop in question closes at half-past eight, the average duration of the lighting would only be 2½ hours, so that lighting it by means of alternate currents would be a very wasteful proceeding. It is, therefore, now proposed to have recourse to a battery of accumulators to be charged during the day by the continuous-current machines, which are kept at work for the purpose of lighting the underground portion of the markets. The accumulators will always be in connection with the low-tension mains, and it is estimated that a battery of 100 accumulators weighing 200 kilogrammes each, together with the four Edison dyamos, would be sufficient to supply the 250 kilo-watts required for the 2½ hours' lighting at La Belle Jardinière.

La Compagnie des Forges de Creusot has purchased the Ganz patent rights for France; the Zipernowsky machines and transformers will, therefore, no longer be constructed by the Compagnie Continentale Edison.

CORRESPONDENCE.

ALTERNATING v. CONTINUOUS CURRENTS IN RELATION TO THE HUMAN BODY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having read with interest the Paper on "Alternating v. Continuous Currents in relation to the Human Body," by H. Newman Lawrence and Arthur Harries, M.D., in *The Electrician* of the 4th inst. I trust that a few remarks, if tardy, may not be out of place in connection with an important point raised therein.

While no one can dispute the well-known disparity between the resistance of a human body to continuous and rapidly alternating currents as measured by the Wheatstone bridge, it is unfair to attribute that disparity to any property peculiar to living organisms, unless, perhaps, in much lower degree; for the reason that the same or similar results are obtained if the measurements be made on bodies of animals lately killed, or on moist flesh preserved from the bodies of animals long deceased. The same phenomenon is noticed whenever a polarising electrolyte is measured such as an ordinary water voltameter, and is recognised to be the effect of the counter E.M.F. of polarisation upon the indications of the measuring instruments.

Several hundred observations of the resistance of persons have convinced me that such resistances are at any one time and under any given conditions fixed quantities independent of the strength, direction, or alternation of the measuring current when the effects of polarisation are eliminated. Of course the resistance will vary with the change of condition of the skin under immersion, &c.; but within the limits of observation, the resistance is not a function of the measuring current in strength or direction. In other words, the resistance with alternating currents will be that found in continuous currents.

To eliminate the effect of polarising E.M.F., which subsides with great rapidity on the cessation of the polarising current, it is necessary in using the Wheatstone bridge to balance to what may be called "instantaneous false zero," or such a position of the galvanometer needle as zero, that on releasing the battery key no further temporary throw of the needle in the direction calling for reduction of balancing resistance is discernible. The throw of the needle which generally takes place is evidently due to polarisation E.M.F.; and when this throw is just made to vanish by change of zero, the resistance (always much lower) unplugged for balance is correct. The method may be practised upon any ordinary polarising resistance, and it will be found that the resistance so obtained is independent of the battery power employed or the strength of current passing through the electrolyte. It is, of course, inaccurate when the resistance in any arm of the bridge contains sufficient electrostatic or electromagnetic capacity to produce a throw of the needle on its own account. I venture to believe that if the measurements of resistance offered by persons be made to instantaneous false zero, the

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apparent disparity between the results with continuous or alternating currents will be found to disappear. If there be any due to a special property of living tissue, it will be of much lower order and lesser amount than that under present discussion. I have never been able to appreciate any difference with Wheatstone bridge ratio 1,000 : 1,000 between the limits of 2 and 8 volts of testing E.M.F.—Yours very truly,

Edison Laboratory, Orange, N.J., April 21, 1890. A. E. KENNELLY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It seems that the language of my letter of the 8th inst. was somewhat too elliptical. May I therefore repeat more fully the two points which Mr. Lawrence takes up with an implication of careless reading and inaccurate quoting, which, I think, he can hardly sustain?

The measurements of resistance were made with "alternating currents from an induction coil." Unless this induction coil was really a transformer, *i.e.*, had an alternating current supplied to its primary (which is nowhere stated and is not usual), these currents differ widely from the alternating currents known to practical electrical engineers; and this difference is of such a kind and degree as to produce very different results in Wheatstone bridge measurements of such conductors as the human body, as Mr. Bláthy points out fully in your issue of April 24th. This difference is still more important as regards physiological effects; and it is this one fact which makes the title of the Paper misleading, and invalidates the conclusions as to the danger of commercial alternating currents sought to be drawn from the experiments therein recorded.

Secondly,—The tables. E. and F. appear to show that the average E.M.F. required to produce muscular fixation through dry-hand contacts of the ten persons experimented on was 6·36 volts effective. It is natural to inquire, what is the ratio between the muscular fixation E.M.F. and a fatal E.M.F.? I suggested ten times—under the same conditions, of course. I thought, and think, that this multiplier is large rather than small. Mr. Lawrence draws an analogy between E.M.F. and a dose of medicine. I know nothing of the latter subject, but I fancy that a doctor who had seen one grain of a drug produce temporary tetanus would not care to give a dose of ten grains to the same subject or to one in similar conditions.

To return; to say that 64 or even 100 volts of alternating E.M.F. can give a fatal or serious shock through dry-hand contacts is not borne out by experience; and I believe I am within the mark in saying that 400 to 500 volts is the lowest which has been proved to be fatal to human life. The lowest figure would give a ratio of about 63 times the muscular fixation E.M.F. deduced from the Paper under discussion, which seems extremely large. I take it that this question is one of serious importance, and worthy of accurate inquiry and unimpassioned discussion, which is my only excuse for occupying your space again.—Yours, &c., HENRY M. SAYERS.

Rua da Carvalhosa 79, Oporto, April 29, 1890.

THE DIATHERMANCY OF AIR IN RELATION TO THE EFFICIENCY OF INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I wish to make a few remarks on Mr. Robertson's letter of last week. He has evidently misunderstood my Paper.

By omitting a part of a paragraph he makes it appear that I claim to have discovered something which has "been long known to lamp-makers and used as a rough test of the state of exhaustion."

I said, after the portion quoted, that not having seen any mention of the property in question, I did not know whether my results agreed with those obtained by others, meaning, of course, numerical results which would show the extent to which lamps were affected.

The variable properties of air in this respect were known before the invention of incandescent lamps, and are in some works stated wrongly.

The novelty in my method is that it affords a means of testing which can replace the "rough test" mentioned, and enable manufacturers to test the condition of lamps by an instrument much more sensitive than the bare hand.

Testing by means of sparks from an induction coil is a very imperfect and destructive method. A spark will only pass through a hole in ordinary glass, either one already existing, or one made, or enlarged by the spark itself, the effect being to cause steady deterioration of the vacuum in a lamp so treated.

My statement that lamps with a perfect vacuum attain and lose their incandescence slowly, while others with a less perfect vacuum behave differently, was based on my own observations; and if there are exceptions to this rule, then the property which air possesses of conducting heat more readily as its density increases must be in some cases suspended, as, for example, in the case of the carbon of high specific resistance mentioned in the concluding lines of Mr. Robertson's letter, which will increase in incandescence and as suddenly lose it in a medium in which another carbon performs both operations slowly.

The sudden loss can only be caused by the heat being more rapidly removed than from the other filament, and both being in the same medium makes this difference somewhat difficult to account for.

Mr. Robertson states that the differences in the state of exhaustion between two carefully made lamps are far within the $\frac{1}{10}$in. which I give. I purposely gave only the extremes of the scale; and as the difference between a highest possible and $\frac{1}{10}$in. vacuum is 215 divisions, it is evident the thermoscope would indicate the intermediate state with a little more accuracy than is possible in testing with the bare hand, and without waiting for the bulb to become heated by convection.—Yours, &c., F. HIGGINS.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The Town Council of Godalming invite schemes and tenders for lighting that town by electricity. Particulars and estimates, endorsed "Tender for Lighting," should reach the Borough Surveyor by the 24th inst.

——— Tenders are required for the supply and erection of electric bells at the fire-engine station and in 11 firemen's dwellings adjoining, in Suffield-street, Middleton, and should be addressed to the Chairman of the Watch Committee, endorsed "Electric Bells," and delivered at the office of the Town Clerk, Middleton, by the 17th inst.

SALE BY AUCTION.—Tuesday, Wednesday, Thursday, Friday, and Saturday, the 13th, 14th, 15th, 16th, and 17th May, are the days fixed by Messrs. Wheatley Kirk, Price, and Goulty, for the sale of the valuable rolling mill, plant, machine, tools, engines and boilers, &c., &c., at the High and Low Mills Forge and Chain Works, Gateshead, at present in the occupation of Messrs. Hawks, Crawshay and Sons. The sale commences each day at 10 for 11 a.m. prompt. The catalogue of the sale, which is now ready, consists of 88 pages. Further particulars are given in our advertisement pages.

DISSOLUTION OF PARTNERSHIP.—The dissolution is announced of the partnership of Messrs. Stafford and Eaves, electrical engineers, of Coventry.

AMERICAN ELECTRICAL APPARATUS.—Messrs. Shippey Brothers, Limited, have been appointed sole European agents for the Viaduct Manufacturing Company, and inform us that they will, in future, hold stock in this country of the leading specialities manufactured by this firm. Show rooms have been opened for this department, and a number of new American electrical novelties are, we understand, on view.

ADMIRALTY CONTRACT.—Amongst the recent contracts given out by the Admiralty, one for the supply of a large number of projectors, search lamps, and switchboards, has been entrusted to Mr. Ronald A. Scott, of Acton-hill, W.

MAVOR AND COULSON.—This firm has just secured an important electric lighting contract in the city of Calcutta. The contract is for the lighting of the extensive suite of offices belonging to the British India Steam Navigation Company. It is probable that the installation will embrace about 300 incandescent lamps.

DORMAN AND SMITH.—This firm have recently received some large orders for abroad, one of which is for a consignment of electric light specialities, which includes 5,000 compound porcelain switches, and fuses of a total capacity of some 50,000 lights.

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REMOVAL NOTICE.—The Ward Electric Car Company (Limited) have removed their offices to 38, Gracechurch-street, London, E.C., and have taken premises at Dacre-street, Westminster, S.W., where an experimental omnibus is on show.

PERSONAL.—Mr. J. D. F. Andrews has taken Mr. H. H. Gray, civil engineer, into partnership, and has removed his offices to 41 and 42, Parliament-street, Westminster, where the business of electric engineers will be continued, under the name of J. D. F. Andrews and Co. We understand Messrs. Andrews and Co. are now prepared to supply the trade with their various specialities.

MR. RICHARD CRITTALL.—Mr. Crittall has this week issued an illustrated catalogue of electric light fittings, containing a large number of ornamental designs in wrought iron, copper, brass, and copper and brass combined. The book is accompanied by a full list of prices, which seem very moderate.

THE ROYAL MILITARY EXHIBITION.—This Exhibition was opened on Wednesday last, in the large grounds of the Royal Hospital, Chelsea. The Exhibition will be lit by the electric light, the installation being in the hands of Messrs. Davey, Paxman, and Co.

STRODE AND CO.—We have received from Messrs. Strode and Company their catalogue, in which particulars are given of their dynamos, in Willan's patent combination frames, by which arrangement economy in space and fuel and silent running are obtained. The arrangement is specially adapted for ship lighting. The catalogue contains tables, tabulated price lists, &c., of electric light leads, cables, steam, gas, and petroleum engines, turbines, arc and incandescent lamps, projectors, and hand and automatic regulator lamps. A section of the catalogue is devoted to electric light fittings.

B. BACKHOUSE AND COMPANY (LATE MESSRS. P. F. BUCHNER AND CO.).—This firm, under date May 1st, announces that the reconstruction of the firm, which has been in progress since last autumn, is now complete, and that arrangements for the manufacture of artistic wrought-iron electric light fittings, &c., at their works at Munich are now perfected. These works, which have recently been considerably enlarged, are under the personal superintendence of Mr. Alfred Wahl.

COMPANIES' MEETINGS & REPORTS.

Brazilian Submarine Telegraph Company (Limited).

The thirty-third ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Wednesday, under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. R. Collett) read the notice calling the meeting, and the minutes of the last meeting. The Report of the Directors was taken as read.

The CHAIRMAN: Gentlemen—I have nothing but congratulations to offer you on the state of your affairs which the Report and accounts disclose. During the half-year we have paid you a good dividend; we have largely increased your reserve fund, we have paid off a large portion of the first issue of debentures, and our income has been very satisfactory. I may state incidentally, what of course does not appear in the Report, that the income for the present year is in amount almost identically the same as for the same period of last year. Gentlemen, under these circumstances, I really have not much to say to you. One of my colleagues the other day said I always told you the same thing; but I do not think you will object to monotony when it is monotony of prosperity, and the figures are always on the right side. Our accounts show that there has been a slight increase of expenses this half-year, partly due to the necessity for making new buildings for the accommodation of our staff at some of our tropical stations, and partly to legal expenses incurred in London. The only other subject to which I wish to allude is the competition to which we may be exposed whenever our concession expires. Of course, we cannot prevent the Brazilian Government or any one else from starting a new line to compete with ours. All that we can do is to exercise the greatest supervision and care to see when the time arrives that you are in the best position to meet any competition that may arise. This constantly engages our attention, and I trust we shall be able to see you through the difficulty in a manner that will satisfy you With these observations I beg to move—

"That the Report of the Directors and the accounts to December 31, 1889, now submitted be approved and adopted."

Mr. F. YOULE seconded the motion.

Mr. GAMMON thought that a very large amount was being added to the reserve fund, which was all the larger remembering that the interest which it earned was added to that fund. More was being added to it than was being divided. He wished to ask whether they could give any idea as to the amount to which the reserve fund would be increased, and also whether any idea could be given to the shareholders when the £75,000 which they held in the African Direct Company was likely to yield them a profit.

The CHAIRMAN, in reply, stated that the dividend they had hitherto paid was not one that the shareholders could fairly complain of, and the Directors wished to retain in their own hands the right to increase the reserve to any point they conceived to be necessary. It was to be borne in mind that there was the chance of their having to renew either of the cables. The reserve, too, might become useful in equalising dividends, and in connection with competition a great advantage had been found in other companies to which he belonged from their having large reserves when competition had come upon them. The African Direct Company in the past half-year had brought them in traffic £7,318.

The Hon. ST. JOHN BRODRICK, M.P., added that the position of the African Direct Company, of which he was a Director, since the junction with the Cape had been very satisfactory. Without being able to make any actual promise, he thought they saw their way to paying a dividend on the shares. They had always paid the debenture interest.

Dr. TREWHELLA thought that the policy of the Company, which was a very good one for the most part, should not be altogether in reference to the future. He hoped that at their next meeting, which would be at the end of their financial year, a handsome bonus, more handsome than they had had hitherto, might be conceded to them. The reserve fund now amounted to £308,000, and he would like to know what rate of interest it yielded in the average.

Mr. GRIFFITHS: £3. 10s. 11d. per cent.

Dr. TREWHELLA said this reply corroborated his view that it would be an economy to pay off the Five per Cent. Debentures if they could do so, as in that way they would gain about 1½ per cent., representing the difference between what the investment of the reserve produced and the interest they paid on the debentures. He inquired when the concession would terminate.

Mr. W. S. CUFF said that they were all hoping to see a larger dividend, but at the same time he proposed that they should build up a reserve fund to very much more than it stood at now, even if they were not able to increase the dividend. He regarded the reserve fund as their backbone. The same idea had occurred to him which had been referred to by a previous speaker—whether they could not get rid of the debentures altogether.

The MANAGING DIRECTOR (Mr. Fuller) said that the monopoly which they had under the Brazilian concession would expire in August, 1892, but they had the power to lay cables as long as they liked. The Portuguese concessions would not expire till January, 1895.

The CHAIRMAN said he entirely agreed as to the advisability of diminishing the debenture debt, but it must be remembered that in this matter they were in the hands of the debenture-holders, who could not be compelled to sell their debentures or accept payment for them unless they were brought into the market. They would remember the suggestion which had been made as to the advisability of paying off debentures more rapidly, if they could possibly do so.

The CHAIRMAN put the resolution, and declared it carried unanimously.

Dr. TREWHELLA proposed, and Captain BLAKEY, R.N., seconded, a resolution passing a cordial vote of thanks to the Chairman and Directors for their efficient administration of the Company's affairs in the past.

The motion was carried, *nem. con.*; and the CHAIRMAN having briefly replied, the proceedings terminated.

The West India and Panama Telegraph Company (Limited).

The twenty-sixth ordinary general meeting of the members of this Company was held on Wednesday at Winchester House, Old Broad-street; Mr. C. W. Earle presiding.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting, and the minutes of the previous meeting, which were confirmed and signed as correctly entered.

The Report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—The Report is one which has caused me some disappointment. I do not allude to the falling off in the traffic, because in that respect we compare with a very large increased traffic in the corresponding period, which also showed a considerable increase upon the previous corresponding period. With regard to the increased expenditure for repairs, at this time last year I ventured to impress upon you all the more sanguine views I generally entertained as to our future expenses for the repair of cables. I was then under the impression that what we had done, and the large expenditure we had gone to, and the experience we had gained in the seas in which our cables lie, would have kept down the cost under this head. We find in this half-year that the expenditure has rather exceeded the recent average than been below it, a circumstance which has been somewhat disappointing. At our last two meetings it was urged upon us—and it was very natural that it should be so—to do away, if possible, with one of our two repairing ships. Well, during the year preceding this one we might, perhaps, have been able to get along with only one ship; but, as everybody knows who has anything to do with cables, the uncertainty as to their interruption from breaks or other accidents that may occur to them is very great, and it is impossible to tell what may happen. I will just now allude to the repair statement, and the secretary will show on the chart what cables were interrupted, with the view of your judging how far we could have done with only one ship, as was advocated at the last meeting. Up to the month of December we had only four interruptions to our twenty cables, and we thought we were going to have a good half-year; but on the second of that month the Jamaica Ponce cable was interrupted; this was followed by interruptions of the St. Thomas-San Juan and Jamaica-San Juan on the 6th, the St. Vincent-Grenada on the 13th, the Trinidad-Demerara on the 17th, and the Martinique-St. Lucia on the 18th. Now, with all these interruptions the only colonies that had been cut off from communication during the half-year were St. Lucia, St. Vincent, and St. Barbadoes for one day, and the colony of Demerara for 14 days. I think the rapidity with which these re-

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pairs were made reflects great credit upon our captains and the officers under their command. But it is a very serious lesson that we learn from them, and shows how impossible it would have been to do with only one ship. The fact of these repairs having obliged us to put in no less than 77 miles of new cable, relieves us from the necessity of adding, as we should otherwise have done, to the reserve fund. The reserve fund is created for the purpose of renewing and keeping up the cables; and, of course, if you put in new cable to the extent of 77 miles, charging it to revenue, it comes to the same thing as if we put by sovereigns to meet the renewals. Our reserve fund now stands at the figure we calculated it would be in the present year, and therefore no addition has been made to it by the Directors this half-year. You will notice from the chart that the colonies of Barbadoes and Demerara, both of which are good customers, are only connected by single cables. These have been interrupted from time to time, causing much dissatisfaction, and stoppage of the subsidies, although we always put on sloops to carry the messages, and thereby, as far as possible, to keep up the communication. It has often been impressed upon us by these two colonies that we should extend to them the same advantages that the rest of our system enjoys; and with the view of consolidating our position in the West Indies we have decided to do so, provided that the Governments of these two colonies will assure us of their subsidies for a period of 10 years. Since the expiration of the original grants, they have only guaranteed a subsidy for one year, but we have told them that we could not think of putting down a second cable to connect their colonies upon such an insecure tenure as one year's subsidy, but that if we got it extended for ten years we should do so. Well, gentlemen, we hear that this proposal, after considerable negotiations, has been virtually accepted by these colonies, and we are now waiting the text of the Acts which they have passed in their Legislatures in order to proceed with the new work. I now come to what is, perhaps, the most interesting part of our Report—the reference that it makes to the new competitor that has stepped into our field of operations. Upon one occasion our Report, and I myself, from this chair, warned you that there was a danger looming before us by reason of the presence of French telegraphic interests in the West Indies. Some two years ago a French company laid down a cable to Venezuela. So long as it did not encroach upon our rights we were powerless. The next step taken by this French company was to lay a cable between Martinique and Guadeloupe. These are two of the colonies that hitherto gave us subsidies of £2,000 a year each. The subsidy of Guadeloupe has still several years to run; that of Martinique expired at the end of last year. At the beginning of the year the competing cable had not come into existence, and the colony of Martinique passed its subsidy to us for this year; but on this information reaching the ears of the French Colonial Minister, he sent out instructions ordering the Council at Martinique to re-assemble and reconsider its vote, as he had entered into a contract stipulating that the Martinique subsidy should go to the French enterprise from the beginning of the year; and that colony immediately revoked the grant of the subsidy which had previously been made to us. How far such an act is consonant with justice I will leave you to judge. We entered into a virtual contract for this year, and up to the present time have performed the duties of that contract; and yet, by a stroke of the pen they struck out the consideration upon the faith of which we rendered, and are rendering, services. The French are a very patriotic people, and they will do a great deal for their own country. Their Government assists them very substantially, as you will see by the action I have described, and which has been taken by the Colonial Minister in this matter. I wish that our Government and our Colonies would only show the same preference for English enterprise as the French show for theirs. You have probably noticed that there is shortly to be an International Telegraph Convention. These Conventions or Congresses assemble every five years in one of the capitals of Europe. They are called together by the telegraph departments of the different European Governments. The representatives of submarine telegraph companies are invited to attend these conferences without the right of any vote. I believe that the delegates of foreign Powers must listen to a certain extent to the views of those representing the telegraph cable interests, but they legislate according to their will. Hitherto we have not thought it necessary to incur the expense of sending any special representative from this Company, as some of the members of this Board, who are also Managing Directors of other Submarine Telegraph Companies, have hitherto been good enough to represent us at the same time that they were watching the interests of their own Companies. But on this occasion, what with the French complication and also the fact that the Spanish colonies have joined this international convention (and we are a great deal connected with the colonies of Spain, going as we do to Cuba and Porto Rico), it was thought advisable that I should attend the Conference this year. It was represented to us by the gentleman who is good enough to look after our interests in Paris, that on this occasion it would be important that the Chairman of the Company should proceed to Paris, an opinion endorsed by my colleagues on the Board. I may say that it was rather against the grain; but I have assented to do so, and I hope my attendance will have good results. A little earlier than this time last year I had to go to Madrid upon a question that arose there, and, through the valuable assistance of Sir Clare Ford, our Ambassador, I did something towards safeguarding the Company's interests. I now beg to move—

"*That the Directors' Report and accounts to December 31, 1889, submitted to this meeting be, and the same are hereby, received and adopted; and, as recommended, that a payment of a dividend of 6s. per share on the First Preference shares for the six months to December 31, 1889, and 27s. 6d. per share on account of arrears of dividend on the Second Preference shares, be, and the same is hereby, declared.*"

Mr. W. FORD seconded the motion.

A SHAREHOLDER asked what was the length of the Company's cables.

The CHAIRMAN replied that it was about 4,000 miles.

Mr. JAMESON asked whether the interest on the depreciation fund was added to that fund or included in the general revenue.

The CHAIRMAN: It is added to the depreciation fund.

A SHAREHOLDER asked to what extent the Company's traffic was affected by the French Company.

The CHAIRMAN said the line was only opened in February. It was only a local traffic, the whole of which came to only £400 a year, between the two islands, and the Company got part of it still. It was not a serious matter at present. It was the danger of extensions that the Company had to fear.

Mr. JAMESON: What is the length of the proposed new cables?

The CHAIRMAN: One is 100 miles, and the other 300 miles long.

Mr. ODELL asked what would be the probable cost of the new cables.

Mr. FORD said it would be very unwise to answer such a question.

The CHAIRMAN added that tenders for them would be invited in the usual way. They had got the money for them.

A SHAREHOLDER: The last repair was unexpected, was it not?

The CHAIRMAN: It was by me, because I said at the last two meetings that the cables had got into such a state that they would be less expensive to maintain. I was wrong, as you see, because we had these six breaks in one month.

Mr. FORD said it would be interesting to the shareholders to know that the expenditure on ships and cables during the last year had been very little in excess of the normal expenditure for the last 15 years. He had taken out the figures, and he found that the average amount paid under this head for that period had been £23,416, against £25,156 for the past 12 months. In some years the amount had been greatly in excess of that, showing how very much the repairs varied. For example, in 1882 he found they amounted to £35,600, in 1884 to £28,800, in 1886 to £28,000, and in 1887 they were £24,300, so that they were not this year greatly in excess of the average amount.

The resolution was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. H. WEAVER, Sir James Anderson was re-elected to his seat at the Board; as was also Mr. William Andrews, on the motion of the CHAIRMAN, seconded by Mr. H. HOLMES.

Mr. WHITE afterwards proposed, and Mr. CUFF seconded, the re-appointment of Mr. J. G. Griffiths as auditor of the Company.

On the motion of Mr. GOODSALL, seconded by Colonel MITCHELL, a vote of thanks to the Chairman and Directors was unanimously passed, and the proceedings terminated.

Submarine Cables Trust

The nineteenth ordinary general meeting of the certificate holders in this Trust was held at the offices, Winchester House, Old Broad-street, E.C., on Wednesday; Sir John Pender, K.C.M.G., presiding.

The SECRETARY (Mr. Lewis Wells) read the notice calling the meeting, and the minutes of the previous meeting, which were confirmed and signed as correctly entered.

The Report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: Gentlemen, the accounts which we lay before you to-day compare very favourably with those which were submitted at our last meeting. The revenue has amounted to £23,094, against £19,118 in the previous year—an increase of £3,976. The expenses have been £1,274, as against £1,383, a diminution of £109. We are, therefore, some £4,000 better off than we were this time last year. As stated in the Report, the certificate holders have received interest at the rate of 6⅜ per cent. this year, compared with 5⅝ per cent. last year. We hope to continue to pay at the same, or at a higher rate, until we have liquidated the coupon which is now in arrear. We shall then revert to the regular interest of 6 per cent. which, under our trust deed, is cumulative. As you know, gentlemen, the revenue of this Company depends entirely upon the prosperity of the other submarine companies in which our capital is invested. We are all, I may say, at the present time working in harmony. There is no active competition, and consequently there is no cutting of rates; as long as we work in what I may call this satisfactory business style the chances are that the shareholders will be largely benefited. I have often said, and I repeat it here, that submarine telegraphy is becoming a necessity to the nations of the world. People that use it cannot give it up; and there is always a new *clientèle* cropping up which finds that to live in business the telegraph must be used. Therefore, believing in the progress of trade throughout the world, and seeing that our submarine system touches every civilised part of the world, I think that the Trust is in a very sound position. With these remarks I beg to move—

"*That the Report and accounts of the trustees now submitted to the meeting be approved and adopted.*"

The Most Hon. the MARQUIS OF TWEEDDALE seconded the resolution, which was carried unanimously.

Mr. JEFFERSON proposed, and Mr. CASHMAN seconded the following resolution:—

"*That Mr. John G. Griffiths, F.C.A., and Mr. John Gane, F.C.A., be re-elected auditors to the Trust for the current year, and that their remuneration be the sum of £25 each.*"

On the motion of Mr. JEFFERSON, seconded by Mr. CASHMAN, a vote of thanks was unanimously accorded to the Chairman and Trustees for their conduct of the business of the Trust during the past twelve months

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The CHAIRMAN: On the part of my colleagues and myself, I can truly say that there is no greater compliment that you could pay us than to accept our Report with the few remarks I have made to you as being satisfactory. It shows that you are satisfied, and that you believe that we are doing the best we can for the interests of the Trust. That is very gratifying to us, and we shall continue to act in the same way to command the support and confidence of our shareholders on occasions like this.

The proceedings then terminated.

The House-to-House Electric Light Supply Company (Limited).

The second ordinary general meeting of the proprietors was held at the Central Electric Lighting Station (Kensington), Richmond-road, S.W., on Monday last; Mr. Henry Ramié Beeton presiding.

The SECRETARY (Mr. H. St. John Winkworth) read the notice convening the meeting, and the Report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—In accordance with the Articles of Association the Report and accounts have been issued to every shareholder, so that I shall probably be consulting the convenience of the meeting if I take them as read, and proceed at once to recommend them to your adoption. The first observation I have to make in regard to the accounts is that in the early stages of our business the capital expenditure is necessarily out of proportion to the earning capacity, for the reason that we are called upon to meet, in the nature of the case, a progressive demand, and the form of supply which is most economical in the case of a large demand is different from that in the case of a small one, so that we are practically obliged in the first instance to adopt a capital basis, which is adapted to an ulterior, rather than to an immediate, revenue. This being so, the justification of our accounts is to be sought at a point which is more or less removed; and we must be content to-day, if we are in a position to predicate with certainty that our profits will be such as to permit of a reasonable dividend in the near future, with the assurance of an improvement later on. Now, our present plant is equal to the supply of twice, and our capital capacity is equal to the supply of three times, as many lights as we have on our existing circuit, and this, notwithstanding the fact that we have connected on an average about 1,000 lights per month. I think that these figures are evidence that our progress up to the present has been satisfactory, and I think also that we may look forward to a steady progress in the future. It is always dangerous to prophesy, and never more so than in the case of a new industry in which the conditions are without precedent, and in which, of course, very limited experience is available to guide us; but I can say, with some degree of confidence, that if the rate of progress which has prevailed in the past is maintained in the future, in twelve months from to-day we shall be in the enjoyment of a demand which will ensure us a fair dividend on our capital, and in two years from the present time our profits will be as much as it would ever be prudent to distribute (applause). Of course, we naturally wish that our progress had been greater than it has been; but even in a rich residential district like ours we find that there are many causes which operate to deter custom. In the first place it is our peculiar misfortune that we have to suffer instead of benefiting by the faults of those who are engaged in the same line of business. It is unfortunately true that whereas we have never had a failure of the light, yet the fact that some of the more prominent supply companies have notoriously blundered has deterred many people even in our district from becoming customers. They naturally hold off until they can feel more assurance of continuous and reliable lighting. Then, again, we have to contend with the expense of installing the light, which, of course, operates with added force during the lifetime of existing gas fittings, and during the unexpired portion of short leases; and lastly, we have been prejudiced by an unfounded scare, which has been fostered by interested and unscrupulous persons, of the danger of the current. But, notwithstanding these obstacles, we have confidence in the future of electric lighting. The electric light is healthy and it is clean, and these are advantages which many can afford to pay for, and which when an increased demand enables us to reduce the cost of production, we hope to bring within the reach of a greater number. As an indication of the confidence which is felt by our neighbours in our future, I may mention that, so far as we are aware, every new building in the district is being wired for the electric light, and no gas pipes are being admitted at all. Moreover, we are in a position not only to supply both arc and incandescent lighting, but also motive power, and already among the business premises which we serve we have been asked to provide for this class of custom. I am afraid that some of the shareholders have felt that their attendance here to-day has been somewhat of an inconvenience to them, but the Directors felt that it would be an advantage that they should be able to visit the district and inspect the station. Whatever anybody else may say about us, I think everyone will recognise the excellence of our station; and, after all, mechanical efficiency is at the foundation of prosperity in this business. Our dynamos, which I hope you will see soon, are working now, as they have always done—noiselessly, and with the minimum of supervision—and they have never had any repairs, and, indeed, no work whatever has been spent on them since they started. The excellence of our work, and the unrivalled experience of our engineers, have induced us not only to anticipate success in the field of supply, but also to look forward to building for others similar stations to that which we have built for ourselves. We believe that those who are engaged in overcoming the daily difficulties of supply, and who are called upon to meet the constantly varying conditions of the industry, are best qualified to undertake the work of construction—that no engineer, whatever his theoretical attainments, and that no Construction Company, however extensive its works and resources, can compete in the knowledge which is necessary to the successful establishment of a central station with those who, like the engineers of the House-to-House Electric Supply Company, have been engaged in planning and constructing the earliest and most successful stations, and in conducting their operations ever since. Possessed of these qualifications and encouraged by the action of the Board of Trade in allotting the metropolitan area, we have been forming provincial companies with a view to developing electric lighting generally, and promoting the system and interests of the House-to-House Company in particular in other cities and towns of the United Kingdom. To this end we have appointed qualified agents, who have visited our stations, who have acquired a knowledge of the industry, and who have formed confidence in us. These agents, acting on behalf of such companies, have sought the permission of the local authorities in all the principal centres to apply for statutory powers, and in so doing they have neglected no opportunity of bringing the merits of our station under the notice of deputations from the local authorities. We hope and believe that the expenditure which we have incurred in this direction will bear good fruit; and in support of this expectation, I may mention that we have already obtained the requisite sanction of many local authorities, and in other cases where such sanction has been withheld, we believe that, if the authorities undertake the lighting themselves, we shall get the erection of their station; and if they neglect to apply for statutory privileges, we have the assurance of the Board of Trade that in any application for a Provisional Order which we ourselves may make, due regard will be had to the fact that we have been at considerable expense, and that we have complied with the rules of the department. With the growth of this branch of our business the Directors are of opinion that it will be desirable to separate the supply on the one hand from the engineering or construction on the other; and they have had several plans under consideration to this end, which when the time comes they will submit to the shareholders. With these few observations I beg to move—

"*That the report and accounts be received and adopted*" (applause).

Mr. ROBERT HAMMOND (Managing Director) said he had very great pleasure in seconding the resolution. He felt after the exhaustive speech which the Chairman had made, there was very little else to be said; but he would like to draw the attention of the shareholders to one or two points in the report, and to emphasise them. The first was that they had only for a very short time been in possession of Parliamentary powers. It was true that the Company was formed two years ago, but it soon became apparent, with the very stringent rule which the Board of Trade put forth in reference to overhead wires, that the Company's system of supply must be by means of underground mains; and though they had made application to the vestry in June, 1888, various forms had to be gone through before they could finally get what they had, at the present time—an Act of Parliament, and practically they did not start their station till November last. Under these circumstances, he must say he was inclined to take a very much more sanguine view of their recent progress than the Chairman had ventured to do. In the first place, however, he fully agreed with what Mr. Beeton said that it would be absurd at the beginning of a 42 years' tenure under an Act of Parliament to judge of their future business by the start of only a few months. Having pointed out by means of a chart the growth of the number of the Company's installations from November to the end of April last, he proceeded to say that it would be fair to postulate that what had occurred in that period would happen again, and much more rapidly as the months passed by; and they might fairly say, that, having arrived at a state of things when they could claim that they had now got a revenue which covered all their working expenses and their establishment charges, they had done extremely well after practically six months' working, and at the outset of a career that would run for 42 years (applause). He felt that at the end of another year they would find that their present works would not be sufficient to cope with the demands made upon them; and, as foreshadowed in the report, they would have gradually, as the business developed, to increase their machinery. Going back to the formation of the Company he would point out to the shareholders that the Directors had absolutely carried out the programme which had been laid down. That programme was that the Company was established for the purpose of founding supply stations. It was not established, as most electric light companies were, for the purchase of patents. That was carefully avoided. They found themselves bound to no system at all, and the money which they asked for, and which had been subscribed, had been used for the purpose of founding electric lighting stations. They first founded the station where they now were as a sample of the work they were able to do, and then they prepared the ground for a number of sub-companies, which it was to be hoped would bring them an amount of business; so that on all hands they had carried out the proposals with which they started. Another matter which had not been alluded to by the Chairman, and which did not find a place in the Report, was the fact that not a single Director had received any fees since the establishment of the Company (applause). It was not often that a report came before shareholders in which no Directors' fees appeared; but it was felt by the Board that until the business was thoroughly established they would not call upon the Company to pay the fees which under the Articles of Association were due to them. This circumstance seemed to him to show that the Directors had the very best interests of the Company at heart; and speaking as one who had been enthusiastic in the direction of the electric light supply from the beginning, and who had been connected with the early lighting stations, such as those at Eastbourne and Brighton, he looked forward with a great deal of confidence to the future of the Company (applause).

The resolution was carried unanimously.

On the motion of Mr. JAMES WHITEHEAD, seconded by Mr. W. PAGE, the retiring Directors, Mr. Beeton and Mr. Hammond, were unanimously

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re-elected ; as were also the auditors, Messrs. Theobald Bros. and Miall, on the motion of Mr. PAGE, seconded by Mr. WHITEHEAD.

The company afterwards visited the station, all the details of which were carefully explained by Mr. Hammond and Mr. Hall.

The West Coast of America Telegraph Company (Limited).

The following is the Report of the Directors of this Company for the year 1889, to be presented to the shareholders at the thirteenth ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, E.C., on Wednesday, the 14th inst., at 1 o'clock :—

The gross income of the Company for the year ending 31st December, 1889, was £84,457. 13s. 1d., against £65,714. 15s. 4d. for the year ending 31st December, 1888. Adding £480. 3s. 9d. brought forward from previous year, makes £84,937. 16s. 10d., and after deducting from this the Debenture interest and all other charges, and the two dividends of 5s. each, paid in July, 1889, and January, 1890, respectively, there remains the sum of £30,517. 10s. 3d. Out of this amount, the Directors have transferred £25,000 to the reserve fund, bringing it up to £64,000 ; and recommend the distribution to the shareholders of 2s. per share as bonus, payable on May 21st, to write off £2,000 from the value of the repairing steamer Retriever, thereby reducing her valuation in the books of the Company to £15,000, and leave £517. 10s. 3d. to be carried forward.

The Directors considered it prudent to add the above large sum to reserve owing to renewed threats of competition, which, if carried out, would considerably diminish the revenue of the Company. The land line to Santiago, mentioned in last year's Report, has proved a satisfactory investment. The cables and repairing steamer are kept in perfect working order.

Mr. Henry Roberts and Mr. Frederick Walters are the Directors retiring in rotation ; both are eligible, and offer themselves for re-election. The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs and Co., retires, and is eligible for re-election.

Maxim-Weston Electric Company (Limited)

The following is the Report of the Directors to be presented at the ordinary general meeting of the Company, to be held this day (Friday) at the Cannon-street Hotel, London, E.C., at 12 o'clock.

The Directors have delayed calling the shareholders together in anticipation of being able to report the result of the action against the Managing Director of the late Company. That action is, however, still pending. The Directors, in consequence, are unable to comment upon matters which are still the subject of litigation, and refrain from now giving to the shareholders so full an explanation of the position of the Company as they would wish. The Directors share in the regret which must be felt by every member of the Company, at the result of the Company's operations. The two Directors retiring under the Articles of Association are Messrs. John Marks and James G. Couchman. The auditors, Messrs. Boyce and Ramsay, retire in accordance with the Articles of Association, and offer themselves for re-election.

We give below the extraordinary balance-sheet accompanying the Report, which, as an historical document, is well worthy placing on record in our columns. The footnotes appended by the Auditors are specially worthy of notice. The balance-sheet is dated April 28, 1890, and, as will be seen, is a statement for the period from January 17th to December 31st, 1889 :—

PROFIT and LOSS ACCOUNT, from January 17th to December 31, 1889.

	£	s.	d.
To loss on works	1,019	15	9
„ Directors' fees	458	6	7
„ salaries of managers, secretary and clerks	898	17	6
„ rent of offices	112	10	0
„ stationery and printing	161	3	2
„ advertising	57	5	3
„ insurance	69	6	6
„ travelling expenses	191	1	11
„ patent fees	41	0	0
„ legal and professional charges	315	5	7
„ sundries	49	4	6
	£3,373	16	9
To balance brought down	£3,332	3	9
	£	s.	d.
By transfer fees	39	16	6
„ interest	1	16	6
„ balance carried down	3,332	3	9
	£3,373	16	9

BALANCE SHEET, 31st December, 1889.

LIABILITIES.

	£	s.	d.	£	s.	d.
To nominal capital 500,000 Shares of 3s. each				75,000	0	0
To subscribed capital 268,755 shares of 3s. each	40,313	5	0			
Less calls in arrear	4	15	0			
				40,308	10	0
„ Amount paid on 5,826 shares forfeited				720	17	6
„ Balance of purchase price unpaid, represented by 2s. per share on 37,419 shares unallotted	3,741	18	0			
Deduct amount paid to dissentient shareholders, 24,183 shares at 1s. 6d.	1,813	14	6			
	1,928	3	6			
Add amount realised on sale by liquidators of previous Company of 12,045 shares	872	12	6			
				2,800	16	0
„ Reserve fund*				1,939	9	3
„ Sundry creditors				2,390	18	0
				£48,160	10	9

ASSETS.

	£	s.	d.	£	s.	d.
By plant and machinery*	2,182	0	3			
„ Stock*	4,735	0	1			
„ Furniture and fittings	426	19	0			
„ Stock of stationery	10	0	0			
				7,353	19	4
„ Patents*				26,500	0	0
„ Book debts of previous company unrealised*				4,940	13	6
„ Sundry debtors, including cost of installation				1,582	12	0
„ Cash at bank and in hand				4,451	2	2
„ Balance of profit and loss account				3,332	3	9
				£48,160	10	9

* See Auditors' report on next page.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN

PHOSPHOR BRONZE.

PHOSPHOR BRONZE

BEARINGS, BUSHES,

AND OTHER PARTS OF

ELECTRICAL MACHINERY.

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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AUDITORS' REPORT.

We have examined the accounts of the Company for the period from the 17th January, 1889, to 31st December, 1889, and compared the accompanying balance-sheet with the books, and beg to report as follows:

The plant, machinery and stock have been valued at the same prices at which they were taken over from the previous company. Nothing has been allowed for depreciation.

The patents are put down at £26,500. This is the nominal amount which they cost the Company, such amount representing the difference between the estimated value of the assets and liabilities of the previous company at the date of the transfer.

We are informed that many of the patents had been allowed to lapse prior to the formation of the present Company, and that a lawsuit is pending with regard thereto.

The book debts of the previous company unrealised, amounting to £4,940 13s. 6d., include goods in the hands of Agents abroad, and cash deposited in the bank and in Court pending the result of the Watt actions. Of this amount only a small proportion can be considered good.

A reserve fund was created at the date of the transfer to the present Company, to cover any deficiency that might arise on the realisation of the previous Company's assets and the costs of re-construction. To this account have been charged all losses upon the realisation of such of the book debts as had been settled up to 31st December, 1889, the costs of re-construction, claims upon the previous company paid, and £157 10s. voted by the shareholders as the remuneration of the Liquidators. The balance of £1,939 9s. 3d. remaining to the credit of the reserve fund is not sufficient to meet the deficiency upon the remaining book debts of the previous company, and the cost of pending lawsuits.

Subject to the above observations, the balance-sheet sets forth the position of the Company's affairs as shown by the books on the 31st December, 1889.

(Signed) BOYCE AND RAMSAY,
Chartered Accountants,
(Auditors to the Company).

NEW COMPANIES REGISTERED.

ST. ASAPH IRON, LEAD AND BARYTA COMPANY (LIMITED).—Registered by Richard Chandler, 66, Bishopsgate-street, E.C., with a capital of £30,000, in £1 shares. Object: To purchase, lease, or otherwise acquire land, whether or not for mining purposes, mines, mining rights, water rights, electric power rights in Great Britain or elsewhere.

THE ELECTRIC WELDING COMPANY (LIMITED).—Objects: To acquire inventions, patents, rights, and concessions, for, or in relation to, the utilisation and employment of electricity and any other power for the production and distribution of electric currents, adopting, therefor, an agreement to be made with Edmund Fitzmaurice Lenon, the particulars whereof are not specified in the Articles of Association. Capital £460,000, in £10 shares, of which the first 1,000 are founders' shares. Borrowing limit, one half subscribed capital. Registered, May 1st, by Ashurst, Morris, Crisp, and Co., solicitors, 6, Old Jewry, London.

CITY NOTES, &c.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of April were £3,600, as compared with £4,060 in the corresponding month of last year. The receipts for the month of January, estimated at £3,150, realised £3,176.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of April amounted to £2,089, against £1,867 in the corresponding period of last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of April were £40,696, as against £42,709 in the corresponding period, showing a decrease of £2,013.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of April, 1890, amounted to £55,042, as against £51,452 in the corresponding period of 1889, or an increase of £3,590.

EXETER ELECTRIC LIGHT COMPANY.—We have received this week a prospectus of a further issue of 500 shares of £10 each in this Company. The prospectus sets out that the new issue is intended to provide capital for a considerable extension of the Company's plant and operations. The Directors state that they have large orders on hand for the supply of electricity. The installations erected by the Company have given general satisfaction. £2 is payable on application, £2 on allotment, and the balance of the £10 on the 31st July next. The prospectus does not indicate when applications will close.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company for the month of April amounted to £21,600. From the 1st January to 30th April these receipts amounted to £81,800, against, in the corresponding months of 1888 and 1889, £85,200 and £84,000 respectively.

THE MUTUAL TELEPHONE COMPANY (LIMITED).—This Company has been formed with a capital of £100,000, in 10,000 shares of £10 each. The present issue is 4,500 shares of £10 each, payable £1 on application, £1 on allotment, and the balance in sums not to exceed £2, at intervals of not less than two months. Shares are to be allotted in preference to those undertaking to rent this Company's telephones. The Directors are A. D. Provand, Esq., M.P.; H. T. Gaddum, Esq., J.P.; W. M. Mollison, Esq.; J. R. Paton, Esq.; Councillor James W. Southern. The Company holds a licence from the Postmaster-General, and negotiations are in progress for the opening of exchanges in Yorkshire, Liverpool, London, and the Midlands. The Secretary (pro. tem.) is Mr. J. Vincent Swindells, with offices at 71, King-street, Manchester. The prospectus states that the object of the Company is to provide first-class telephone service, both public and private, and for these purposes the Company intend to undertake the following different kinds of telephonic services:—1. Exchange wires (not exceeding one mile from Central Exchange, Manchester) at £5 per annum to holders of two or more shares and £6 per annum to other renters. (For distances beyond one mile an extra charge will be made.) 2. Extra instruments in other rooms of the renter's office or warehouse for attaching to the Exchange wires at £1 each per annum. 3. Telephones from one part to another of the same building, requiring two instruments, at about £2 per annum. 4. Telephones communicating from one building to another, or between warehouses and works at a distance. These would require two instruments and the communicating wires, and would be charged according to distance. The Directors further announce that they intend at the earliest possible date to establish a complete system of inter-town communication.

STOCK EXCHANGE.—Application has been made to the Committee to appoint a special settling day in the:—Ordinary shares, Nos. 1 to 31,436, and Preference shares, Nos. 40,001 to 54,285, of Woodhouse and Rawson United (Limited); and to allow the following securities to be quoted in the Official List:—Western and Brazilian Telegraph Company (Limited)—further issue of 489 shares, Nos. 91,559 to 92,047.

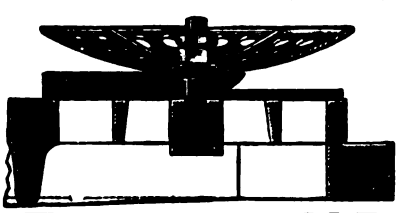
VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY (LIMITED).—The prospectus of this venture has been issued this week. The present issue is of £70,000 Five per Cent. First Mortgage Debentures of £100 each (at 85 per cent.) and for 70,000 £1 shares. The Directors are Sir Douglas Fox, Francis Bennoch, Esq., J. W. Philipps, Esq., M.P., and W. P. van Laar, Esq.; the Manager in Venezuela is James A. Derrom, Esq. (formerly manager of the Inter-Continental Telephone Company); the consulting engineer is Dr. John Hopkinson, F.R.S.; the secretary is John Simpson, Esq.; and the offices are at Winchester House, Old Broad-street, London, E.C. The Company takes over the business, which is in full working order, of the Inter-Continental Telephone Company of New Jersey, U.S.A., and a Venezuelan Government Concession. The Company's system aggregates in length about 1,200 miles, and covers the larger part of the Venezuelan Republic. The number of subscribers on February 28th last was 1,511, and the net revenue for 1890 is estimated to produce about £8,200, leaving a surplus available for dividend of £4,700.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month ended April 30th were £5,275.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended April 30th show an increase of £197 as compared with the corresponding period of last year.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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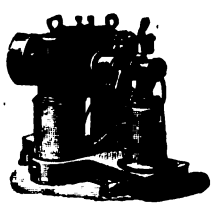
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, April 30.		Price Wednesday, May 7.		Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending May 7.	
										Highest.	Lowest.
£			**TELEGRAPHS.**					£ s. d.			
1,381,380	Stock	12/6	Anglo-American	50	51	50	51	5 7 10	Jan., Apr., July, Oct	..	..
2,809,310	Stock	25/0	Do. Preferred	85	86	85	86	6 7 11	,, ,,	86	85½
2,809,310	Stock	..	Do. Deferred	15½	16	15½	16	..	February	15½	15½
250,000	£100	4%	African Direct, 4 per Cent. Debentures	98	101	99	101	3 19 3	January and July	99½	..
130,000	10	3/0	Brazilian Submarine	12¼	12⅝	12½	12⅝	5 17 8	Mar., June, Oct., Dec.	12⅝	12½
69,200	100	5%	Do. 5 per Cent. Bonds	101	103	101	103	4 17 1	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	105	108	105	108	4 12 7	June and December	..	..
16,000	10	9/0	Cuba Submarine	11	11½	11	11⅜	7 16 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	17⅜	18½	17½	18¼	5 8 1	,, ,,	17⅞	17½
12,931	5	2/4½	Direct Spanish (£4 paid)	3⅜	4½	3⅜	4½	5 3 6	March & September	4½	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 14 11	Jan., Apr., July, Oct.	10⅝	10½
400,000	10	2/6	Eastern	14¼	14⅜	13⅜	14	4 12 10	,, ,,	14⅛	13⅝
70,000	10	6%	Do. 6 per Cent. Preference	14⅜	15½	14⅜	15½	3 18 8	,, ,,	15⅛	14½
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.. xd	106	108	107	110	3 12 9	May and November	109	107½
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension xd and bonus	14½	14⅝	14	14½	4 18 3	Jan., Apr., July, Oct.	14⅜	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 per Cent. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	106	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	102	105	102	105	4 15 3	,, ,,	104⅛	104
180,227	10	2/0	Globe Telegraph and Trust	8⅞	9⅛	8¾	9⅛	5 18 2	Jan., Apr., July, Oct.	9	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15⅛	14⅜	15⅛	3 19 5	,, ,,	15⅛	15
150,000	10	5/0	Great Northern xd	15½	16	15½	16	4 13 6	Jan., July, and April	15⅝	15⅜
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102	105	102	105	4 15 3	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,600	25	37/6	Indo-European xd	38	40	38	40	6 5 0	April and October	40	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅛	8	7⅛	8	5 0 0	April and October	8	7⅞
3,381	£100 Cert.	..	Submarine Cables Trust	110	115	110	115	5 4 4	,, ,,	..	..
15,609	£10	3/6	West African	9½	10⅛	9	10	..	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	..	..
30,000	10	5/0	West Coast of America	8	9	6⅞	7⅛	6 13 4	January and July	7⅛	6⅞
150,000	100	8%	Do. Debentures 8%	121	126	117	122	6 11 2	June and December	120	..
88,321	10	Nil.	West India and Panama	2⅜	2⅞	2⅜	2⅝	..	..	2⅝	2⅜
84,563	10	12/0	Do. 1st Preference 6%	11½	12	11½	12	5 0 0	April and October	11⅝	11½
4,669	10	10/0	Do. 6 per Cent. 2nd Preference	14	15	14	15	4 0 0	..	..	..
64,572	15	6/0	Western and Brazilian	10½	11	10½	11	6 17 0	May and November	10⅞	10⅝
26,986	7½	6/0	Do. 5 per Cent. Cumulative Preferred	6⅜	7	6½	7	..	..	6⅞	6⅜
26,986	7½	7/6	Do. 5 per Cent. Deferred	4⅛	4⅜	4	4⅛	..	..	..	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage .... xd	122	126	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,350	14/0	5%	Consolidated Telephone Const. and Maintenance..	⅛	¼	⅛	¼	..	Yearly	⅛	..
220,000	£1	3%	Oriental (11s. paid) xd	⅛	¼	⅛	¼	4 8 3	Yearly	..	..
386,875	5	3/0	National	5⅜	6⅛	5⅜	5⅝	..	June and December	5⅛	5⅛
49,525	5	..	Do. New	4⅝	5	5⅛	6	..	..	5⅜	..
15,000	20	..	Do. 6 per Cent. Cumulative 1st Preference..	12⅛	12⅜	12⅛	19⅜	4 14 1	June and December	12⅛	12⅜
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference..	10	11	10	11	5 9 1	,, ,,	10⅛	10⅞
209,750	1	..	South of England, Ordinary	⅛	¼	⅛	¼	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3⅛	3⅜	3⅛	3⅜	6 0 0	..	..	..
55,000	5	2/0	United River Plate	4⅛	5	4⅜	5⅛	..	Jannary and July	4⅛	4⅜
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅜	2⅝	2⅛	2⅜	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5⅛	5⅜	5⅛	5⅜	..	..	5⅜	..
42,863	5	..	Westminster Electric Supply	1⅞	2	1⅞	2	..	..	2	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅛	2⅜	2⅛	2⅜	..	..	2⅜	2⅛
63,416	2	1/2	Do. Preference	1⅝	1⅞	1⅝	1⅞	..	..	1⅞	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5⅛	5⅜	5⅛	5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..		..		..	..	..	..
409,000	10	..	Electric Construction	9⅜	10⅛	9⅜	10⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5⅛	5⅜	5	5⅛	..	..	5⅛	5⅛
20,000	5	..	Fowler-Waring Cables	2⅛	2⅜	2⅛	2⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works..	18	19	18	19	5 5 3	February & August	18⅛	18½
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid) xd	4⅛	4⅞	4⅛	5	..	..	5⅛	4⅞
37,350	12	20/0	Telegraph Construction and Maintenance	44	46	44	46	5 3 11	March and July	45⅛	44½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	..	..	..



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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 626.—Vol. XXV. FRIDAY, MAY 16, 1890. Price Fourpence.

NOTES.

The discussion which arose on Dr. Lodge's Paper at the Institution on Thursday last was noteworthy, not only in consequence of the value of the results of experience brought forward, and for the suggestiveness of many of the speeches, but even more so for the conciseness of the remarks themselves. It was, indeed, rather a pity that a discussion of so high a character should have been brought to a close before showing any signs of flagging, although, no doubt, the desire of the President to end the proceedings at a reasonable hour did much to contribute to the brevity and pointedness of the remarks. If the same results could be always thus brought about, the shortening of the discussion would be attended with two advantages: it would not only raise the standard of the remarks; but, what is more important still, it would render it possible for more Papers to be read in the course of the Session. The number of Papers read during the year at the Institution of Electrical Engineers is still remarkably few, although greater than used to be the case.

The remarks which were made did not refer so much to Dr. Lodge's protector as to those the capabilities of which have already been tested by long use. Even Sir William Thomson was no exception; for, although fully recognising the theoretical merits of the new lightning guard, he preferred to speak about the existing methods of protection, and expressed the opinion that the most reliable way of safeguarding a cable from the effects of lightning was by means of a fine wire such as is used in the Saunders protector. The suggestion of Sir William Thomson that a condenser could be used in series with the fine wire, when considered in connection with Mr. Saunders' statement that in the whole of his unique experience he had known no case of injury caused by lightning to condensers connected with cables, naturally leads us to inquire to what extent condensers can be subjected to alternating potentials without injury. The subject is one about which very little is known, and which will become of increasing importance as alternating-current devices depending on the use of condensers are more and more developed. The frequency of the alternations caused by a lightning discharge is so enormous that the potential absorbed by the condenser in developing a moderate current need be very little, and the risk of a breakdown is consequently but small. It would be far otherwise if the oscillations were slow, for the condenser might then absorb all the potential of the flash. Thus a microfarad condenser will only need one volt at its terminals to pass a current of 600 amperes if the alternations are as frequent as 100 million a second, but if the frequency is only 100 a second it will require a million volts to produce that current

Dr. Lodge's protector seems no exception to the rule that there is nothing new under the sun. Prof. Hughes, in the course of his interesting remarks, succeeded in showing that several existing forms of lightning-guards were essentially the same in principle as that of Dr. Lodge, although the principle on which they are based has not till now been recognised.

General Webber justly complimented Dr. Lodge on the suggestive nature of his Paper, and the various speakers bore practical witness to the truth of the remark by directing the discussion to an important matter, alluded to by the author, and on which we commented last week, viz., the protection of electric lighting circuits from the effects of lightning. Prof. Ayrton pointed out the unsuitability of fine wire protectors for such purposes; and Mr. Mordey remarked that the chief danger was of an indirect nature, and arose from the dynamo current following the arc started by the flash.

Although the exhibits at the Royal Society's *soirée* yesterday evening comprised little that was absolutely novel, they were of considerable interest, and a very large proportion of them were of an electrical character. Several of the exhibits have recently been brought before the Physical Society, notably the magnetic survey maps of Profs. Thorpe and Rücker, Prof. Silvanus Thompson's new optical rotator, and Mr. Gregory's electric radiation meter. Mr. Shelford Bidwell showed his experiments on the electrification of a steam jet, and Mr. Vernon Boys' series of photographs taken by electric sparks attracted much attention.

Among the exhibits of a more practical nature were various forms of Dr. Lodge's new lightning protector, and a new material for bushing shafts shown by Mr. Killingworth Hedges. This consists of a mixture of steatite and carbon, and the bushings can be put in just as cast, giving no further trouble for lubrication. They were shown fitted to very fast running shafts. They require renewing after a time, but meanwhile the expense and trouble of lubrication are avoided. Mr.

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SYMONS also exhibited a very elaborate apparatus for recording the various disturbances during a thunderstorm.

PROF. ROBERTS-AUSTEN experimentally showed the recalescence phenomena occurring during the cooling of iron and steel, by the aid of a thermo-electric joint of very simple construction, which seems admirably suited for the measurement of high temperatures, since it is very sensitive to rapid changes of temperature, and may be calibrated by the air-thermometer to any desired degree of accuracy. A very complete exhibit of apparatus was also shown by Mr. G. BURCH, illustrating the use of the capillary electrometer for investigating rapid changes of potential.

THE obscurity which surrounds many phenomena connected with alternating currents will be in some measure cleared up by an attentive study of Dr. FLEMING'S Paper "On Prof. ELIHU THOMSON'S Electro-Magnetic Induction Experiments," which we reproduce in this issue. The effect of self-induction in retarding the phase of Foucault currents, and consequently causing magnetic repulsion between the inducing and induced currents, was first called attention to by Dr. FLEMING in connection with his galvanometer for alternate currents; but it is to the interesting experiments of Prof. THOMSON that we mainly owe our present knowledge of these intricate phenomena. The very striking nature of the results obtained is in itself sufficient to draw close attention to the experiments, irrespective of the many important applications to practice which may result from them, one of which, the WRIGHT-FERRANTI meter, we describe in another column.

IT is worth while, in connection with this subject, to recall the mechanical interpretation of electro-magnetic repulsion according to the radiation theory of electricity. It was a prediction of MAXWELL that any electro-magnetic radiation, such as a beam of sunlight, would repel any body on which it fell, and at the surface of which it was reflected or absorbed. In Prof. THOMSON'S experiments the radiation proceeds from the primary to the secondary circuits, and the repulsion between them arises from the mechanical reactions due to reflection at the surface of the secondary coil.

THE important task of verifying some of Prof. THOMSON'S results by careful measurement has been undertaken by M. BORGMANN, who, in a number of the *Comptes Rendus*, describes several quantitative results he had obtained. The primary magnetising current was measured by a SIEMENS dynamometer, and the repulsive forces exerted on a disc were weighed by means of a delicate balance. The repulsive force was found proportional to the mean square of the primary current; it diminished as the distance between the disc and magnetising solenoid increased; it diminished with the diameter, and increased with the thickness of the disc. For discs of the same dimensions, but of different metals, the repulsion diminished with the specific resistance, although in a less proportion, owing to self-induction; and, as the frequency of the current was increased, the forces were found to diminish, the product being about constant. Although several of these results are only what theory would have predicted, it is the first time they have been experimentally shown.

IN another column will be found an interesting paper by M. SPECNEW upon the influence of electricity on vegetable growth. The scale on which M. SPECNEW'S researches were carried out and the period over which they extended impart more than a purely scientific interest to the striking results obtained by him, though the day when the British farmer will increase the productiveness of his land by placing it within an electrified wire cage is perhaps somewhat distant.

WE have received from the LANE-FOX Electrical Company a pamphlet containing reports from several eminent authorities upon the LANE-FOX patent, No. 3,988, of 1878. In its final form this patent merely claims the employment of secondary batteries as "reservoirs of electricity," in conjunction with lamps run in parallel across constant potential mains. The reports in question, which are dated 1886, all agree as to the originality and utility of the system of distribution which was proposed in 1878 by Mr. LANE-FOX; and on this point indeed there is probably general agreement. We understand, however, that the LANE-FOX Electrical Company has been formed, amongst other things, for the purpose of exacting royalties from those whom they consider to come within the scope of this patent Whatever the reasons may have been, the fact remains that this LANE-FOX patent has for twelve years been kept in comparative obscurity, and is now flourished in the faces of those who have laboriously worked out the essential details of a system of which the bare outlines only were shadowed forth by Mr. LANE-FOX. Under these circumstances, therefore, it is perhaps satisfactory that the patent will expire within the next two years.

IN his interesting Paper on "The Aim and Scope of Higher Technical Education," read before the Society of Arts last week, Prof. PERCY F. FRANKLAND urged our old universities, with their immense *prestige*, to adapt themselves to the needs of the present industrial era by developing their teaching in the direction of higher technical education. As Prof. FRANKLAND remarked, the training at present in vogue at Oxford and Cambridge tends to engender a distaste for the practical; yet a large proportion of those who are trained in this manner have ultimately to take to some practical career. In its laudation of German methods and organisation, Prof. FRANKLAND'S Paper resembled many others on the same subject. If ever technical education comes to be recognised in this country in a manner satisfactory to its advocates, it is to be hoped that this admiration for what is German will not result in mere imitation, and to the sacrifice of freedom and originality for the sake of a rigid uniformity of instruction.

THE "startling conception of the human race united in bonds of instantaneous intercourse" is due, we need hardly say, to the brain of Mr. HENNIKER HEATON, who, in *The Times* of Saturday last, *apropos* of the Paris Telegraphic Convention,

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explains to the British public how easy it would be to reduce international telegraphy to a penny per word. Between Great Britain and France, Holland, Belgium, and Germany, he is sure it could be done at a profit; and he arrives at this gratifying result by adding the respective local charges together and ignoring the cables. A similar process of reasoning, with a dash of personal bias against the proprietors, would reduce the cable charges to British India and the Colonies correspondingly. There may be something to be said for cheapening international telegraphy, just as something may be said for reducing international Customs. Mr. HENNIKER HEATON might address himself to the latter question with advantage to his object; for at present every Government is in the habit of taxing foreign telegrams much as it does foreign products and manufactures, and probably for the same reasons. Mr. HEATON thinks that the Government telegraphs should not be worked for profit. Possibly the Governments might agree with him; but what they would say is, that telegraph business conducted as a means of raising revenue is a very inoffensive form of indirect taxation, and that if this were abandoned something else would have to take its place.

THE validity of contracts made by telephone has recently been called in question before the United States Courts. In an action brought by the Paddock-Hawley Iron Company against Messrs. PULLIS BROTHERS, it appeared that some iron was ordered by telephone, but that when the bill was sent in Messrs. PULLIS BROTHERS demanded a reduction of some 10 per cent., in virtue of an agreement to that effect which they said had been made by telephone. In reply to this the plaintiffs asserted that there were only two members of their firm empowered to make such contracts, and that neither of them ever heard of this telephonic communication until after the controversy arose. The Court held that while a teleponhic contract was as binding as any other, the same rules of evidence applied; and as there was not sufficient evidence to disprove the assertion of the plaintiffs, it was decided that the bill must be paid in full. The moral obviously is, avoid making contracts through the telephone alone.

Folkestone.—The Corporation has granted Messrs. Crompton and Co. an extension of time for completing the electric light until December 31st.

The Lighting of the City.—The House-to-House Company have given notice of their intention not to proceed any further this Session with the Bill deposited by them for power to supply electricity within the City.

Dublin.—At the last meeting of the Corporation the report of the Electric Lighting Committee recommending the utilisation of some Corporation land in Fleet-street as a site for a central station, was adopted.

Bolton. — The Town Council were on Tuesday informed by the Board of Trade that the application of the Lancashire and Cheshire House-to-House Electricity Company for the Provisional Order had been refused.

Dewsbury.—At the last meeting of the Town Council it was decided, on the recommendation of the Gas and Water Committee, to apply for a Provisional Order to enable the Council to supply electricity within the borough.

Electric Signals for Mines.—A special monthly meeting of the National Association of Colliery Managers was held on May 3rd, at Messrs. John Davis and Sons', All Saints' Works, Derby. The hall was arranged with specimens of Messrs. Davis's apparatus for electric signalling in collieries.

Conference of Australian Postmasters-General. — A conference of the Postmasters-General of all the Australasian Colonies, with the exception of New Zealand, will, says a Reuter's telegram, meet at Adelaide on the 20th inst., to consider, amongst other things, the question of cable rates.

National Telephone Electrical Society.—On the 2nd inst., the members of this Society held their first annual *conversazione* at the Colonnade Hotel, New-street, Birmingham. In the course of the evening Prof. J. H. Poynting (one of the local directors of the National Telephone Co.) showed some very interesting and novel experiments.

London Chamber of Commerce.—Amongst those elected members of the London Chamber of Commerce at the last Council meeting were C. A. Parsons and Co., electrical engineers; Shaw and Connolly, electrical engineers and cable manufacturers; and Montagu J. Scott (Montagu J. Scott and Co.), electrical engineer and contractor.

The French Telephones.—The committee nominated by the French postal telegraph department to study the question of improving the telephone service have tested 20 different transmitters on the Paris-Brussels trunk wire (424 miles). One instrument proved itself decidedly the superior, and 50 of this type will now be used experimentally at Paris, Marseilles, and Lille.

Vacant Appointment.—The Committee of Management of University College, Nottingham, require the services of a properly qualified Professor of Engineering, who will have charge of the new technical schools and engineering laboratories. The salary is £300 a year, with a share of the fees, guaranteed at £100 for the first year. All further particulars may be obtained of the Town Clerk, Guildhall, Nottingham.

The Railway Rates Inquiry.—A Correction.—In the report in our last issue of the proceedings before the Board of Trade Inquiry into the question of Railway Rates, Mr. A. P. Trotter is represented as saying that the value of cotton-covered wire was about £72 per ton at the present moment. The sentence, on p. 15, should read: "Cotton-covered wire is worth about £90 per ton; the price of the bare copper wire being about £72."

The West of England Telephone Company.—Arrangements have been made by this Company by which all the principal Government offices at Devonport are placed in communication with the Telephone Exchange. The Chamber of Commerce were negotiating with a view to such an arrangement when the Telephone Company stepped in and solved the difficulties by placing these offices on the Telephone Exchange without charge.

Institution of Electrical Engineers.—On Friday last Mr. Müller read his paper on "House Telephones" before the students of the Institution; General C. E. Webber in the chair. An interesting discussion followed, in which the Chairman, Messrs. Raphael, Horn, Bone, Foyster, and Cross took part. Mr. Stephens will read a Paper on "Marine Propulsion by Electricity" on the 23rd inst. This will be the last meeting of the students before the summer vacation.

Birkenhead.—A special meeting in committee of the Town Council was held on Monday afternoon, to take into consideration the alterations made by the Board of Trade in the Birkenhead Electric Lighting Provisional Order. The Town Clerk said there was scarcely a single clause which had not been altered in some way or other. After a lengthy discussion as to the advisability of proceeding with the Order in its altered form, it was decided, with only two dissentients, to go on with it.

A New Application of Electric Heating.—According to certain Italian journals the dome of St. Peter's is cracking in a somewhat serious manner. *La Lumière Electrique* states that a similar state of things was discovered about 100 years ago, and was remedied by encircling the dome with a strong band of metal. This band was heated, and its contraction on cooling was found to be sufficient to close up the fissures. Our con-

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temporary suggests the use of electricity if a similar method should be tried in the present case.

The Shetland Cables.—Mr. Lyell asked the Postmaster-General on Monday whether he was aware that the telegraph cables between Mossbank and Ulsta, and between Yell and Uist, in Shetland, had both been broken for some time, thereby causing much inconvenience; and whether he would have these cables repaired without delay. Mr. Raikes, in reply, stated that the cable ship of the Post Office had gone into dock for certain necessary repairs, but he trusted she would be able to proceed to the Shetlands next week.

The Mexican Telegraph System.—In his message to Congress on April 1st, General Diaz stated that the telegraph system had been extended and improved, 938 kilometres of new lines having been constructed from September up to date. The federal telegraph lines had reached a total length of 23,000 kilometres, without counting the double and treble lines, which measure 6,200 kilometres. There were, he said, besides, 28,900 kilometres of telegraphs and telephones belonging to single States, private individuals and railways.

Fire at Messrs. Robey's Works.—Late on Tuesday night a fire occurred at the engineering works of Messrs. Robey and Co., Lincoln, where more than 1,100 hands are employed, and the flames were not subdued until an early hour on Wednesday morning. The fire broke out in the steam sawing and planing mills, and when discovered had obtained possession of the central portion of the building, at each end of which were drying sheds, in which were stored large quantities of timber. The damage estimated at nearly £8,000, is covered by insurance.

The Electric Light in the Suez Canal.—In his last report to the Foreign Office the British Consul at Port Said gives the following interesting figures with regard to the application of the electric light to vessels navigating the Suez Canal at night. In 1887 395 steamers used the light; in 1888 the number rose to 1,611, and in 1889 a total of 2,445 vessels navigated the canal with its aid. The average time of transit has been reduced to 22½ hours. The shortest time taken by a steamer in passing through the canal in 1889 with the aid of the light was 14¾ hours.

Telephone Rates in Switzerland.—Under a law recently passed by the Swiss Federal Council, an annual subscription entitles a telephone subscriber to 800 conversations, with a supplementary rate of 5 francs per 100 conversations. For interurban telephone systems the rates are: For a conversation of three minutes 30 centimes up to 50 kiloms., 50 centimes up to 100 kiloms., and 75 centimes for greater distances—all of which are calculated "as the crow flies." The new law appears to operate in a satisfactory manner, and the lowering of the charges has produced an appreciable increase in the receipts.

Damages to a Post Office Cable.—In the Queen's Bench on Tuesday, the case of the Attorney-General *v.* Taylor was an information by the Crown against the master of the "Olive Branch," for so negligently navigating his vessel as to damage a cable laid in the bed of the Medina River, Isle of Wight, and conveying messages to and from Osborne. It appeared that the anchor of the defendant's vessel caught in the cable and caused damage which cost £29 to repair. The defendant pleaded not guilty, and contended that the position of the cable was not sufficiently indicated by the buoys placed by the Postmaster-General. The jury took this view, and returned a verdict for the defendant.

Paddington Vestry.—At a meeting of this Vestry on the 6th inst., a communication was received from the Board of Trade with reference to the resolution of the Vestry discontinuing its opposition to the application of the Metropolitan Electric Supply Company for a Provisional Order, stating that, although the rules of the Board of Trade require that the consent of the Local Authority be given to an application for a Provisional Order at a special meeting, of which one month's notice had been given, they would be prepared, if the Vestry desired it, to proceed with the settlement of the Metropolitan Electric Supply Company's Order, pending the passing of the formal resolution. A motion of adjournment was carried by 17 to 10 votes

Siemens-Martins Compressed Steel Shafting.—Compressed polished shafting of a high quality not requiring turning is now being introduced in Germany by Reimbold, of Mettmann. These shafts are produced to exact diameter, perfectly round and straight. They are made of pure soft Siemens-Martins steel, 20 to 25 per cent. carbon, admitting of being welded and tempered. They have, it is said, 50 per cent. greater tenacity than ordinary shafts. From experiments made by Messrs. David Kirkaldy and Son, of London, it was shown that the limit of elasticity of these shafts was 79,200lb., that of ordinary iron being 23,800lb, and of patent rolled shafts 60,600lb. The relative strength therefore is—iron 1,000lb., rolled shafts 1,505lb., compressed polished shafts 1,612lb.

Edinburgh Chamber of Commerce and the Telephone System.—The Edinburgh Chamber of Commerce has forwarded a memorial to the Postmaster-General with reference to the acquisition of the telephone system by the Government. By acquiring the telephone system at the earliest possible date, the memorialists are of opinion that the Government will purchase proportionately much cheaper than in seven years hence, and that the telegraphic revenue, which, they say, is now suffering from telephonic communication, would be sustained and increased by the additional revenue arising from the extended telephonic system, and by economies which will arise from the two systems being operated in harmony. A similar memorial has been sent to the Lords Commissioners of Her Majesty's Treasury.

Church Lighting.—An interesting installation of the electric light is to be seen at the Holy Trinity Church, Sloane-street, Chelsea. The lighting arrangements have been planned and carried out by the Brush Electrical Engineering Company, in conjunction with Mr. J. D. Sedding, the architect of the building. The nave is lighted by five elaborate lanterns, fitted with 8 and 16 candle-power lamps. The morning chapel and aisles are supplied with lanterns of a less elaborate design, also fitted with a number of 8 and 16 candle-power lamps. The entrance lobbies, gallery stairs, corridors, vestries, musicians' galleries, and parish room are all lighted with groups of three and four lamps, arranged on artistic wrought-iron electroliers, designed and manufactured by the Brush Company. When completed the installation will consist of 130 16 candle-power incandescent lamps, and 103 8 candle-power ditto. The supply of current is derived from the mains of the Chelsea Electric Supply Company.

The Non-Conductivity of a Vacuum.—In a recent Paper in Wiedemann's *Annalen* on "The Electrical Conductivity of Gases," T. Homen denies the validity of Foeppl's so-called experimental proof of the non-conductivity of a vacuum described in Vol. XXXIII. of the *Annalen*, and of which an abstract was given in *The Electrician* of June 1, 1888. Homen points out that the length of path to be traversed by the discharge in Foeppl's experiment must have been at least 13 metres. Now, his own recent experiments show that in an electrical discharge through rarefied gas there is an addition to the true ohmic resistance, a resistance of the nature of a counter E.M.F., and for a length of path of 13 metres, and a pressure equivalent to 0·09 millimetre of mercury, the value of this counter E.M.F. would be about 5,200 volts, and at this pressure the counter E.M.F. diminished as the pressure increased, it would probably be greater for higher vacua. The E.M.F. of about 270 volts employed by Foeppl could not, therefore, be expected to produce a discharge.

Chinese Telegraph Convention.—In answer to Sir J. Lubbock, Sir J. Fergusson stated in the House of Commons, on Thursday last week, that the arrangement between the Chinese Government, the Northern Telegraph Company, and the Eastern Extension Company was signed on August 10, 1887, and purposed to provide for a fixed rate on through messages from Europe to China, by whatever route transmitted, until 1903. The Convention was, however, made subject to approval by the British and Russian Governments, and Her Majesty's Government have not given their consent to it, and the whole matter is for the present in abeyance. The consent of Her Majesty's Government would not be given to any agreement without full

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consideration of all the interests involved and consultation with the representatives of British commerce.

Electricity on the Stage.—In the opera of "Ascanio" there is an interesting application of electricity to stage purposes. The lighting of the torch of Phœbus is effected by an incandescent lamp enclosed in red transparent framework representing flames; the lamp being supplied with current by a battery of accumulators contained in the handle. The accumulators are six in number, and are of the Planté type. The plates are 5 cms. high and 7 cms. broad and 1·5 mm. apart, and are rolled round one another. The active surface is about one square decimetre per cell. The cylindrical containing vessels are of thin glass, surrounded with gutta-percha. They are 7 cms. high by 2 cms. in diameter. The battery is divided into two groups arranged one above the other. The cells are all connected in series, and are capable of furnishing 3 amperes at an E.M.F. of 10 volts for 30 minutes.

Electric Lighting in St. George's, Hanover-square.—In answer to a question by Mr. Leveson-Gower, Sir M. Hicks-Beach stated in the House of Commons on Monday that he had been urged by the Vestry of St. George, Hanover-square, to grant a Provisional Order allowing a third company to supply electrical energy in the parish, in addition to the two companies, the London Electric Supply Corporation and the Westminster Electric Supply Corporation, already possessing such powers. He was not, however, prepared to interfere with the arrangements made in the metropolis last year, until the companies to whom powers were then granted had been allowed a reasonable time for proving their ability to discharge their obligations. He had, however, informed the companies in question that he should not be disposed to adopt this course another year unless they could prove that they were in a position to supply energy in the district.

Belgian Lightning Statistics.—According to some statistics published by the Société Belge des Électriciens, 229 lightning strokes were reported in Belgium during 1888, or more than double the number of the previous year. Three well-authenticated cases of globular lightning were reported. Near Antwerp, a well running along a ditch was struck by lightning, and a number of fish were killed by the flash; a military engineer stated that the water was turned a bluish tint, and gave off sulphurous fumes. The Château de Moulbaix, in Hainault, was struck by lightning and burnt down, the damages amounting to over half a-million francs. In only one instance was any damage done where there existed a lightning conductor erected in the manner laid down by the Académie des Sciences. The exception was the destruction of an anemometer at the Brussels Observatory, the instrument in question, however, being a long way from the conductor.

The International Telegraph Conference.—The following letter from Sir James Anderson appeared in *The Times* of Wednesday:—

"Sir: In your issue of the 10th inst. Mr. Meyer, of 16, Exchange-buildings, Liverpool, says that he is informed on good authority—first, that there is a proposal to be submitted to the Conference to reduce the limit from ten to eight letters in code language; and, second, that an authorised code of 100,000 words is to be issued. Neither of these propositions has been, to my knowledge, brought forward by any one of the States represented at the Conference, and the companies have never entertained such ideas. He next says that in 1886 I 'maintained that the public should be warned that, sooner or later, the present abused code system should be stopped.' What I really said was that 'the commercial public should be warned that, sooner or later, the present abuse of the code system will be stopped, to the great inconvenience of those firms who are building up a huge mass of made-up words, syllabic combinations having the appearance of words only, and unknown to any language. This practice, which is growing, is unfair, if not illegal, and contrary to the convention by which all telegraph administrations are bound, and will some day have an abrupt ending, especially if ever there is Government control of any kind.' As far as we know, there is no one thinking of interfering with the use of legitimate words which are to be found in the eight authorised languages."

The sittings of the Conference, which commence to-day, will be held in the Salle de Manège of the Louvre, and the opening meeting will be presided over by M. Jules Roche, Minister of Commerce.

The Central London Railway Bill.—The Select Committee of the House of Commons on the Central London Railway Bill sat on Tuesday for the purpose of going through the clauses of the Bill. The Committee passed a new clause, which provided that the frontagers should receive no compensation for the use of the subsoil, but should be compensated by the Company should any damage be done to cellars or other property by the removal of subsoil. The Chairman, after hearing a statement by Mr. Greathead, the engineer, to the effect that the City and Southwark line would be open to the public in a month or two, decided that no prospectus should be issued or capital raised until that line had been worked for a period of at least three months. Mr. Freeman then said that the County Council wished to insert a clause compelling them to set their stations back in a similar manner to Charing Cross. The Chairman said the Committee were of opinion that the clause proposed by the Council, by which they had power to require the promoters to set their stations back when necessary, was a reasonable one. Mr. Freeman said he was prepared to accept the clause provided the Council gave them notice as to which stations they wished set back. Mr. Cripps, on behalf of the Council, promised that due notice should be given within three months of the passing of the Bill.

Severe Thunderstorms.—During a severe thunderstorm last week Sanquhar Parish Church was struck by lightning. The northern spire was the point of impact, the electricity then passed through the belfry and tower to the western vestibule, and after destroying wainscoting, plaster, and gas pipes, blew down the right-hand door, and forced its way into the church. Here the discharge divided, one portion demolished a pew, and made its way to earth by blowing a stone right out of the thick wall close to the surface of the ground. The other portion apparently crossed the church, for many seats and portions of the ceiling were more or less damaged, and every window in the sacred edifice suffered, close on 200 panes of glass having been destroyed. The church and vestibule is said to present the appearance of a building that has undergone bombardment. —On Tuesday evening last week a severe thunderstorm broke over Preston, in the course of which three persons were struck by lightning.—On Wednesday last week Irvine was visited by a storm. About six o'clock the lightning struck Fern Bank House, in Bank-street, damaging the gable and chimney. One of the copestones on the roof of the house was thrown a distance of 20 yards.—On Thursday last week violent thunder storms broke over Wales. Two girls at a farm known as Pantgwyn were struck, and the upper portion of the house in which they were was partly wrecked. In Carnarvonshire a quarryman, working at the Nantyfron Quarries, Talysarn, was struck by lightning and killed.

The Destruction of Telegraph Insulators.—Insulators have long been considered by the public as proper objects on which to experiment in the ancient art of stone-throwing, and in Belgium it would seem that the peasants have a special predilection for this kind of sport. M. Emile Pierard, telegraph engineer to the Belgian Government, reports that owing to the great destruction of telegraph insulators it became necessary to employ some of an unbreakable nature. It was found, however, that these insulators, which were sunk in a protecting cover of galvanised iron, were both extremely heavy and extremely costly. Another system was, therefore, adopted. It was thought that the large white insulator generally employed naturally attracted the attention of individuals of a destructive turn of mind, and it was decided to experiment with one of a less obtrusive colour. The porcelain enamel was coloured a greyish brown by mixing a silicate with it. This process did not impair the insulation properties in any marked degree, and the colour of the posts being also a greyish brown, it was difficult to distinguish the insulator from its support. A line 22km. long was selected, and provided with 102 insulators of each kind, arranged alternately. In one year 25 of the ordinary white insulators were broken, but only 13 of the coloured ones. Taking into account the somewhat higher price of the coloured insulators, but not the cost of labour in replacing the broken insulators, these figures mean an economy of about 42 per cent. All broken white insulators are now replaced by brown ones, and if these are broken protected insulators are substituted.

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MAGNETISM IN IRON AND OTHER METALS.*—XVII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from Vol. XXIV., page 643.*)

§ 73. **Curves of Permeability and Susceptibility.**—The behaviour of magnetic metals during the imposition of magnetic force is sometimes exhibited graphically in other ways. Instead of drawing a curve to show the relation of **B** or of **I** to **H**, as has been done in the examples which have been given, we may draw a curve showing the relation of κ or of μ to **H**. This method of representing the results of experiment was used by Stoletow.† Another, and better plan, due to Rowland,‡ is to represent μ in relation to **B**, or κ in relation to **I**. These may be called permeability curves and susceptibility curves respectively. The following are a few examples. :—

§ 74. **Susceptible Curves for Wrought-iron Wire.**—Fig. 40 shows two curves of κ and **I** for the experiment described above in § 66, where the same piece of wrought iron was tested, first in the soft annealed state, and again after being hardened by stretching. Curves μ and **B** would have the same form, since in wrought iron μ is almost exactly $4\pi\kappa$, and **B** is almost exactly 4π **I**.

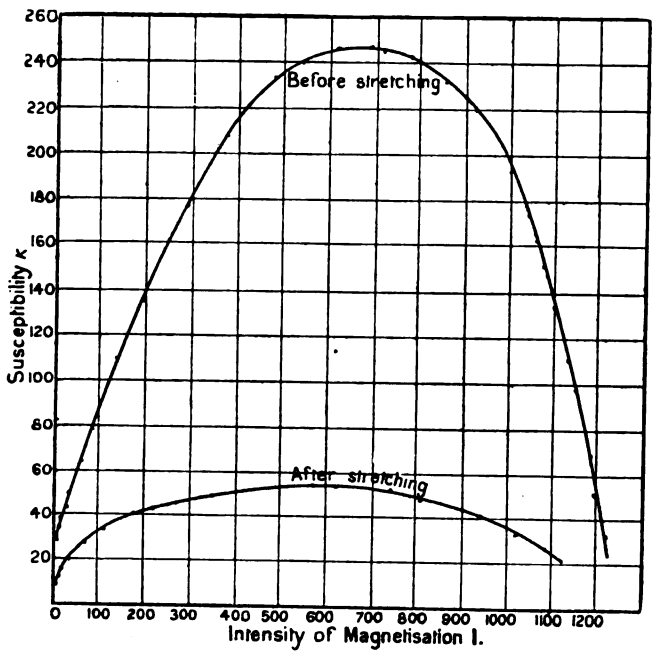

Fig. 40.—Relation of κ to **I** in iron before and after stretching.

The approximate symmetry which a curve of this type exhibits about an inclined straight line through the apex was noticed by Rowland, and led him to devise an empirical formula, from which, by extrapolation beyond the limits of experiment, a limiting or saturating value of **B** or of **I** might be deduced. It has, however, been shown by other observers, that when the magnetic force is sufficiently raised the curves cease to be even approximately symmetrical; the empirical formula then fails, and it is not possible by producing the curve beyond experimental values to find a limiting intensity of magnetisation. There is a true saturation value of **I** (not of **B**), as will be shown later; but it cannot be found in the manner suggested by Rowland, because the curve of κ and **I** or of μ or **B** bends out under high forces, becoming concave on its upper side. This feature will be seen below in the corresponding curves for nickel and cobalt.

§ 75. **Permeability Curves for Nickel.**—Fig. 41 gives three permeability curves for a nickel rod in the annealed state, tested within a yoke:—The lowest, shown by a full line, is the curve got when the rod was tested under ordinary conditions; the other two, shown by dotted lines, relate to tests made when the rod was subjected to compressive stress. An account will be given later of the effect of stress on the magnetic qualities of iron, nickel, and cobalt; meanwhile it may suffice to explain that nickel is extremely sensitive to stress, its susceptibility being greatly reduced by tensile stress, and greatly increasing by compressive stress. The upper and lower dotted curves relate to compressive stresses of 6·8 and 3·5 kilogrammes per sq. mm. respectively.

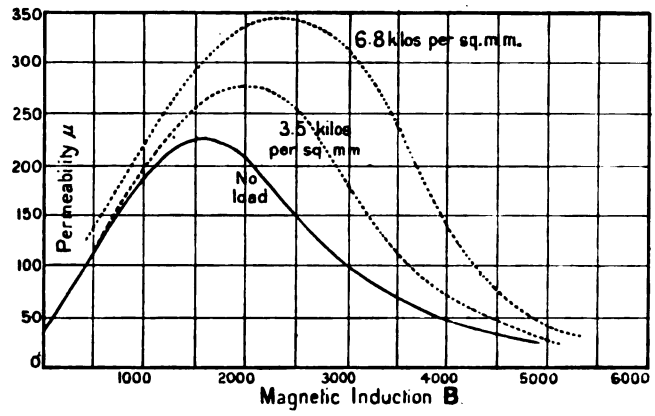

Fig. 41.—Permeability of nickel in the annealed state.

§ 76. **Permeability Curves for Cobalt.**—Fig. 42 shows in the same way two permeability curves for a rod of cast cobalt, tested in a yoke. In this experiment the rod was tested first under ordinary conditions of no stress, and then under a series of loads producing various amounts of compressive stress. The full line is the curve for no load; the dotted line is for a load of 16·2 kilogrammes per square millimetre. The curves cross, showing that under weak magnetic forces cobalt has its permeability increased by the presence of compressive stress; but under sufficiently strong forces the reverse is the case.* In a later chapter it will be shown that a similar reversal of the effects of stress occurs in iron.

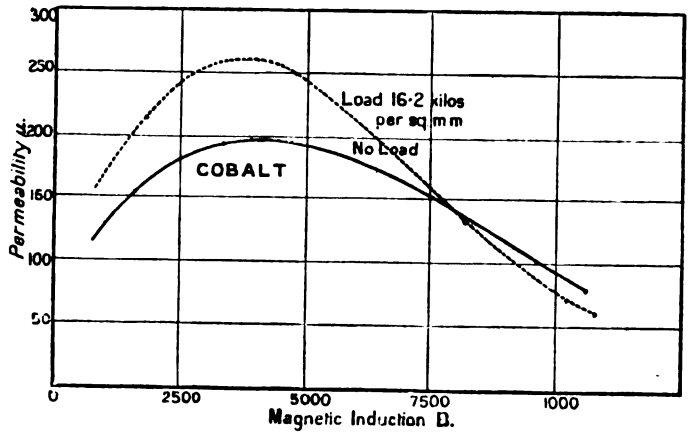

Fig. 42.—Permeability of cast cobalt.

§ 77. **Magnetic Hysteresis.**—The curves which have been drawn to show the effects of cyclic magnetising processes in iron, steel, nickel, and cobalt, have this important feature in common, that there is a tendency on the part of the metal to persist in any magnetic state which it may have acquired, which is exhibited whenever an alteration begins to be made in the character of the magnetising process. Thus, when the magnetising force has been raised to its highest value, we find, on beginning to reduce the force, that the magnetism tends to remain. It does

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† *Phil. Mag.*, January, 1873.

‡ *Phil. Mag.*, August, 1873.

* In a Paper by Mr. C. Chree, published in abstract in *Proc. Roy. Soc.*, December 19th, 1889, the same conclusion is stated, along with other results of experiment on the influence of pressure on the magnetic qualities of cobalt. The experiments with cobalt described in the text, and illustrated in Figs. 39 and 42, were made in 1888 by the writer and Mr. W. Low They have not been previously published.

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not all remain, but the rate at which it disappears during withdrawal of the magnetising force is notably less than the rate at which magnetism was being acquired duringimposition of the force, especially at the beginning of the withdrawal. The existence of residual magnetism when the force is wholly withdrawn is one result of this reluctance which the metal shows to change its magnetic condition. But the results of this tendency go further. If, for example, after withdrawing the magnetising force, we begin to re-apply it, we find in the early stages of the process the same reluctance to change; the metal begins to regain magnetism, but not so fast as it was losing magnetism during the last stages of the removal of the force. The rate, however, improves, and when the force has been completely restored we find that the piece has recovered all, or nearly all (sometimes even a little more than all), the magnetism it lost while the force was being withdrawn. The curve of magnetisation comes back to the same, or nearly the same, point as that from which it started; but its path during the process of return differs entirely from its path during removal of the force. The two curves form a loop, and any intermediate value of the magnetic force is associated with different values of the magnetisation during the two processes.

Moreover, this description applies equally to the effects of *any* cyclic variation of magnetic force, provided the range through which the force is varied be not exceedingly small. Starting from any condition of magnetism and of magnetising force, if we remove and re-apply a part of the force, or if we apply and remove a supplementary force, and repeat the process until its effects become cyclic, we find that the two stages of the process may be represented by two curves, which do not coincide, but differ in a way which may be concisely described by saying that there is a tendency, at each change of process, for the preceding magnetic condition to persist. The changes of magnetism lag behind the changes of force. This tendency has received the name of *magnetic hysterēsis*, from ὑστερέω, to lag behind.*

(To be continued.)

THE APPLICATION OF ELECTRICITY TO AGRICULTURE.†

BY N. SPECNEW.

Electricity has already been applied to numerous commercial purposes, and in this article I propose to study its influence on plants and its application to agricultural purposes. Ever since electricity has been a science its effect on the growth of plants has been the object of much research. The early investigations, however, resulted in contradictory results, which may be explained by the then imperfect state of electrical science, and by the embryonic conditions of its technical applications. It was owing to this state of affairs that Jolabert, Nollet, Mainbray, Achard, Berthollon, and Pardini Van-Marum, affirmed that electricity favoured the development of seeds and accelerated the growth of plants; whilst Ingenhouse, Van Trootswyck, Sylvestre, Senebier, and, to some extent, Decandolle, categorically denied the influence of electricity. The experiments of these *savants* were evidently inexact, and were carried out in a too limited manner; though, on examining them more closely, we find manifest indications of the influence of electricity. Gradually, however, scientific investigations established in a definite manner the incontestable fact that electricity had a beneficial effect on vegetation. To this result the works of Sir Humphry Davy, Bischoff, Humboldt, Wollaston, and especially Becquerel, largely contributed. But these scientists only occupied themselves with the theoretical side of the question; and it is only since 1845 that the first practical experiments in electro-culture have been undertaken. At this date, side-by-side with barren attempts to utilise gigantic electro-static machines, as suggested by Williamson, we hear of the application of a current of electricity produced by two metallic plates, one of zinc and one of copper, placed in the soil, and united by a wire. This method was first employed in England in 1846 by Sheppard, then by Forster in Scotland, and in 1847 Hubeck in Germany surrounded a whole field with a network of wires. Unfortunately, the results of these experiments were published in terms too vague to be of much use. Sheppard came to the conclusion that his experiments showed that electricity only increased the return from root plants, while grass perished when placed close to the electrode. He also asserted that one-third of the plants which developed were inferior to those which had been under the influence of the electric current. According to Hubeck, seeds developed more rapidly, and buckwheat gave a larger return; but in all other cases the electric current produced no result. At the same date the experiments of Prof. Fife were going on in England, and those of Otto von Ende in Germany. These experiments gave negative results, and even led these scientists to advise the complete abandonment of attempts to apply electricity to agriculture.

After a long interval of time we have the investigations of Fichtner, who employed a battery, the two wires of which were placed in the soil parallel to one another. Between these wires, and parallel to them, peas, grass, and barley were sown, and in every case the crop showed an increase of from 13 to 27 per cent. when compared with the ordinary methods of cultivation.

These experiments, and a number of others, led me to investigate the influence of electricity on plants in every state of their development; but I will content myself in this article with describing only those experiments of practical interest.

I. This experiment showed that by submitting different seeds to the action of an electric current their development is rendered more rapid and more complete. I employed in these experiments seeds of haricot beans, sunflowers, winter and spring rye. In every case twelve groups, containing 120 seeds each, were taken and submitted to the action of the current. Twelve exactly similar groups were not submitted to the action of the current, but, with this exception, were treated in identically the same manner. Both lots of seeds were first plunged into water until they swelled. The seeds were then submitted to the action of the current in the following manner:—When still wet they were introduced into long glass cylinders open at both ends. Two copper discs were introduced at either end, and were pushed in until they compressed the seeds. Rods attached to these copper discs were connected to the poles of an induction coil. The circuit contained an ammeter, and the current was kept on for one or two minutes; immediately afterwards the seeds were sown. The temperature was kept during the whole time that they were growing at 6° to 8° Réaumur (45° to 50° F.). These experiments were repeated ten times, and the results in the table below are most striking. I have also to add that the plants which resulted from the electrified seeds were more developed; their leaves were far larger and their colour brighter than in the case of plants resulting from the non-electrified seeds. The current had no effect on the yield.

——	Peas.	Beans.	Barley.	Sunflowers.
	Days.	Days.	Days.	Days.
Electrified seeds developed in	2·5	3	2	8·5
Non-electrified seeds developed in..	4	6	5	15

II. A second series of experiments was carried out with large plates (·445 metres × ·712 metres) of zinc and copper which were placed in the soil at the ends of the plots, the rods connected to their upper faces being united by a wire. This disposition was, therefore, equivalent to a battery (zinc | earth | copper), the current of which passed from one plate to the other through the ground. This method was applied more especially to pot herbs and flowering plants. The experiments were carried out at the Botanical Gardens at Kiew. The influence of the current was manifested by a larger crop and by the growth of vegetables of enormous dimensions.

* *Proc.* Roy. Soc., No. 216, 1881, p. 22; *Phil. Trans.*, 1885, p. 524.
† From *La Lumière Électrique.*

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III. In a third series of experiments the idea was to apply electricity on a large scale, and current electricity was replaced by static electricity. These experiments were carried out on a site situated in the Government of Pskow. In order to understand them better, it is necessary to remember the effect which has been established by experiments, viz., that the slow discharge of static electricity facilitates the assimilation of nitrogen by plants. It is for this reason that plants which are grown in a Faraday metallic cage contain 50 per cent. less organic matter than the plants which are grown in the open air.

On the different plots of earth sown with different seeds (see table below) we placed insulating rods, at the top of which were placed collectors, shaped like crowns. All these collectors were united by means of wires. Atmospheric electricity was thus collected above the seeds, and they matured in the midst of a highly electrified atmosphere. The results of this form of electro-culture are shown in the table. The figures give the averages of five years. All the plots between which comparisons are made were under identical conditions. These figures show, indisputably, that there is a considerable increase in the yield, whether of seed or straw; it was also observed that ripening was more rapid, especially for barley, which, in many instances, ripened twelve days sooner with electro-culture. Another important phenomenon was also observed. Potatoes were seldom diseased when grown by electro-culture; instead of 10 to 40 per cent. of them being bad, only 0 to 5 per cent. were so. These properties of electricity deserve all the more attention, since there are experiments which prove the beneficial effects of electricity on vines attacked by phylloxera. The enormous importance of these facts is self-evident; they seem to offer a new means of combating the microscopic diseases which attack vegetable growth.

A very practical question is—How much does electro-culture cost? I am only able to give the cost of experiments undertaken by myself. The cost of the two metallic plates in Experiment II. is about 16s. The installation of these plates does not require much time nor much technical knowledge, and it must be remembered that once *in situ* the plates are good for several years. The electro-static experiment No. III. was more costly, since it was necessary to have from 50 to 60 insulated rods per dessatin (2 acres). Each collector costs about 8s. But in this case also the expense once incurred the installation lasts for some time. I trust these experiments will be repeated on a still larger scale, and that some day we shall see electro-culture assume large proportions.

Plants.	Quantity of seed sown, in funts.	Mode of culture.	Crop per dessatin. Seed in funts.	Crop per dessatin. Straw in funts.	Percentage gain due to electro-culture. Seed volume.	Seed weight.	Straw weight.
Rye	430	Ordinary	2,565	5,600	128	128	160
		Electro-culture	3,280	8,960			
Corn ..	480	Ordinary	2,560	5,000	156·3	156·1	108
		Electro-culture	4,000	5,080			
Oats ...	630	Ordinary	3,045	3,800	157·4	161·6	154·7
		Electro-culture	4,932	6,000			
Barley ...	430	Ordinary	2,064	5,000	148	155	117·8
		Electro-culture	3,195	5,880			
Peas.....	500	Ordinary	3,760	5,200	122·5	122.3	123
		Electro-culture	4,692	6,400			
Clover ...	50	Ordinary	880	10,400	232	231	117·8
		Electro-culture	2,040	12,200			
Potatoes	3500	Ordinary	35,000	3,600	111·3	111·4	133·8
		Electro-culture	39,000	4,800			
Flax.....	320	Ordinary	1,600	12,360	142·3	147·2	111·4
		Electro-culture	2,300	14,360			

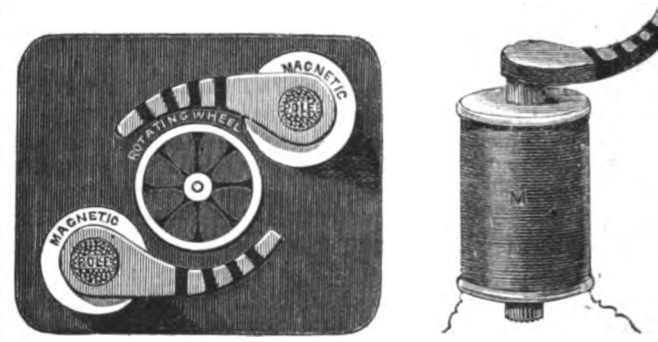
NOTE.—1 funt = ·9 lb.; 1 dessatin = 2 acres (approximately).

Thomson-Houston Electric Railways.—The following figures with regard to the Thomson-Houston Electric Company's traction work may be of interest. Up to April 1, 1890, this Company had 61 roads in operation, with 665 cars and 463·56 miles of track. They have under contract 39 roads, with 431 cars and 385·20 miles of track. The total is:—100 roads, 1,096 cars, 848·76 miles of track.

THE WRIGHT-FERRANTI ALTERNATE-CURRENT METER.

We give this week a brief illustrated description of an ingenious form of alternate-current meter which has recently been devised by Messrs. Arthur Wright and S. Z. de Ferranti. The meter was described by Dr. Fleming at the end of his interesting lecture at the Society of Arts, on Wednesday evening, and it forms a beautiful practical application of the principles underlying Prof. Elihu Thomson's remarkable experiments.

In the accompanying figures we have a rough diagrammatic representation of this meter. It consists in its latest form of a pair of vertical electro-magnets, the magnets having divided iron cores. To the poles of these magnets are attached curved horns of divided iron which lie in a horizontal plane. These curved horns are magnetically throttled at intervals along their length with copper bands. The curved horns embrace a circular space in which can revolve a light copper or iron shallow cylinder of thin metal. This cylindrical band forms the periphery of a light wheel capable of rotation on a vertical axis. Geared to this axis is a counting mechanism. The axis also carries a vane having mica blades.



The Wright-Ferranti Alternate-Current Meter.

The electro-magnetic principle, said Dr. Fleming, may be briefly described thus: The throttling of the curved iron horns causes the rapidly reversed magnetism to take the form of a lateral diffusion of lines of force from the sides of the horns. In effect a series of oppositely-named magnetic poles travels along the horn from the base, where it is in contact with the top of the electro-magnet, to the tip. These poles are represented by a series of bunches of lines of force, setting out laterally from the sides of the horn, and travelling up it. The lateral passage of these lines of force through the metal band which forms the rim of the movable wheel generates in it eddy currents. These are continually repelled by the moving field producing them, and hence a motion of rotation is given to the wheel by the alternating magnetism of the magnetic poles.

The speed of rotation, being retarded suitably by the vanes, can be made to be proportional to the current strength of the current exciting the magnets, and hence the total turns of the wheel in a given time to the total electric quantity flowing through the meter.

ON PROF. ELIHU THOMSON'S ELECTRO-MAGNETIC INDUCTION EXPERIMENTS.*

By J. A. FLEMING, M.A., D.Sc., M.I.E.E., Professor of Electrical Engineering in University College, London.

I. In the Paris Exhibition of 1889, and in the United States Court, many present will, perhaps, recollect to have seen a collection of electrical apparatus, contributed by Prof. Elihu Thomson as his private exhibit. These pieces of experimental apparatus constituted the appliances for illustrating some highly remarkable and interesting facts in electro-magnetic induction. It is more than probable that very many persons interested in electrical discovery either did not find, or did not happen to see in action, these instruments, or perhaps had not the opportunity to see them at all.

* A Paper read before the Society of Arts, May 14, 1890.

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By the kindness of Prof. Elihu Thomson, to whom I am indebted for the loan of the apparatus, it is in my power to repeat some of these experiments before you to-night; and my obligations are likewise especially due to Mr. Ernst Thurnauer, the engineer of the European Thomson-Houston Electric Light Company, for affording me his valuable aid in bringing them before you, and to Mr. Garfield, of the Thomson Electric Welding Company, for assisting me in the preparation of the experiments. A few introductory remarks will be essential, in order that I may carry the whole of my audience with me in subsequent explanations; and these remarks will refer to that which is so very familiar a subject to every electrician, viz., the mutual induction of electric circuits. Before me lies a very large bobbin, or spool, wound over with two insulated copper wires. These wires were wound on the spool together, and for convenience sake we will distinguish them by calling them A and B (*see* Fig. 1). Bear in mind that the wires or circuits are insulated from each other throughout their entire length, but lie closely adjacent on the bobbin. I can at pleasure insert a large bundle of soft iron wires tied up together into the hollow split brass tube which forms the body of the spool. The ends of one wire, say A, are connected to the terminals of a glow lamp, and I can pass or interrupt an electric current which traverses the other circuit, B, and a second glow lamp in series with it. You will note at once what happens when I start or stop the electric current in the circuit B. The lamp connected to circuit A flashes up momentarily at the instant when the current *begins* to flow in circuit B, and also when it *ceases* to flow; but whilst the current flows steadily in the circuit B and illuminates the lamp in series with it, the lamp in series with circuit A is not illuminated at all. We have here a lecture experiment illustrating the familiar classical discovery of Faraday of the mutual induction of two electric circuits, viz., that the starting or stopping of an electric current in one circuit induces at the instant of commencement or cessation a brief secondary current in another closed adjacent circuit. I shall not take up time by dwelling on the historical details of this fundamental fact. You know them well.

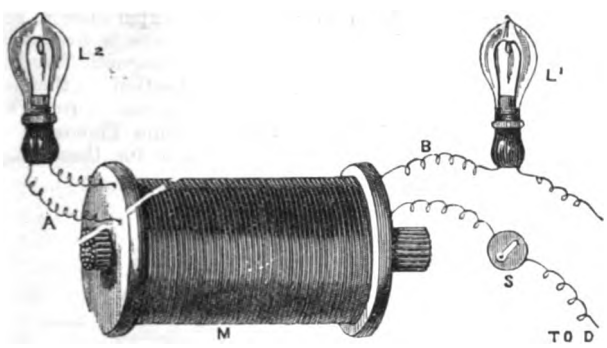

FIG. 1.

If instead of starting and stopping a continuously flowing electric current through the circuit B, and observing at each "make" or "break" a brief secondary current in circuit A, we supply the circuit B with an *alternating* electric current, one of which the direction is rapidly reversed many times in a second, and connect as before a glow lamp in series with circuit A, we find that this lamp glows continuously whilst the alternating current flows in circuit B. This also is familiar to us all. If in our first experiment we had employed, as a current detector in the secondary circuit, not an incandescent lamp, but some kind of galvanometer capable of indicating the direction of the induced electric current, we could easily have established for ourselves the fact that at the instant when the continuous electric current *begins* to flow in the circuit B it generates an oppositely directed induced secondary current in the circuit A, which is merely a transient current. At the instant when the continuous current is interrupted in circuit B it gives rise to a similarly directed transient induced electric current in the circuit A. These momentary currents in A are called the *inverse* and *direct* secondary currents, induced by the commencement or cessation of the continuous primary current in circuit B. If the primary current is rapidly reversed, as in the case of an alternating current, then the secondary current consists likewise of a rapid succession of currents alternating in direction. In most of our experiments this evening we shall employ an alternating current having a "frequency" of 90 per second—that is to say, changed in direction in the circuit 180 times in a second—and provided for us by the kindness of the London Electric Supply Company. If such an alternating current traverses a primary circuit it induces a secondary alternating current of the same frequency in an adjacent secondary circuit, and this secondary periodic current may be made to induce in another circuit a tertiary current of like frequency, and this again a quaternary current, and so on; these successive orders of induced currents being, as it were, the children, grandchildren and great-grandchildren of the primary parent current to which they owe their birth (*see* Fig. 2).

The same large spool of insulated wire will provide us with the means of illustrating another important fact. I join up the two wires A and B into one length, so as to form one continuous bobbin of wire, and connect this great spiral of wire with a couple of glow lamps, one being in series with the wire spiral, and the other being in parallel with it (*see* Fig. 3). On sending a steady current through the system, it divides between the wire spiral S and the lamp L_1, and I adjust the strength of this current so that the lamp L_1 is barely visibly red-hot. On interrupting suddenly this electric current, the lamp L_1 flashes up for a moment. We recognise that we have here to consider an inertia effect familiar to us as the effect of the "self-induction" in the long coil of wire. Audiences in this room have

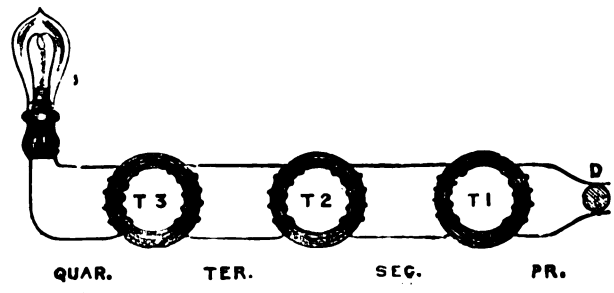

FIG. 2

been so carefully informed on many past occasions by brilliant and capable teachers that I may spare you a reiteration of elementary facts concerning the self-induction or inductance of conducting circuits, and take it for granted that everyone here is intimately acquainted with them, and that you will recall to your recollection that when an electromotive force acts upon any closed electric circuit generating in it an electric current, this self-induction exhibits itself by delaying or retarding the rise of the current strength to its full or its maximum value; and that, similarly, when the electromotive force is withdrawn, it operates to give the current a persistence or to retard the rate of reduction of the current strength. The convenient term "time-constant" of a circuit is employed to denote that time, expressed in fractions of a second or any other unit, which must elapse before a current rises to a certain definite fraction of its full value, when a steady electromotive force acts upon that circuit. I will next beg you to turn a

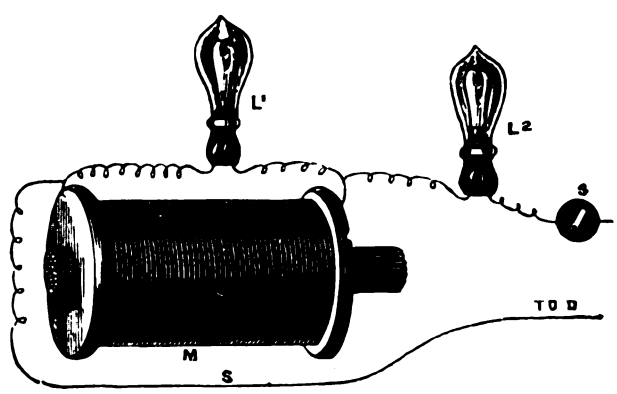

FIG. 3.

moment's attention to the electro-dynamic actions or forces which are brought into play when a circuit of any kind is subjected to electro-magnetic induction in a magnetic field. Consider, for instance, a ring of copper hanging in front of the pole of an electro-magnet (*see* Fig. 4) having the plane of the ring perpendicular to the lines of magnetic force proceeding out from the pole. Let the magnet be an electro-magnet, and let the pole be suddenly made a north or marked pole. Lines of magnetic force are thrust into the aperture of the ring. This magnetic flux, in accordance with a well-known law, generates an inductive electromotive force which causes a transient current to flow round the ring in a counter-clockwise direction, as looked at *from* the north magnetic pole. The ring becomes virtually a *magnetic shell*, having a north pole facing the north pole of the exciting magnet. By the fundamental laws of action, between currents and magnets established by Ampère, the ring experiences a slight repulsive force, due to the electro-dynamic

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action between the current in the ring and the magnetic pole. The generation of the momentary induced current in the ring is accompanied by an electro-dynamic impulse tending to thrust it away from the pole. Suppose, next, that the electro-magnet is demagnetised. The ring has generated in it a reverse induced current flowing in the same direction as the hands of a clock move when looked at from the magnetic pole. This is also accompanied by an electro-dynamic attraction of the ring towards the pole, but which is much more feeble than the previous repulsion. These attractions and repulsions are well seen when small disks of copper or aluminium are suspended in front of the poles of a powerful electro-magnet, which is alternately "made" and "broken." They have been particularly investigated by Mr. C. V. Boys.*

I will now ask you to consider what would happen if the coils of the electro-magnet were traversed by an alternating current? Furthermore, we shall first suppose that the copper ring has a zero time-constant; that is to say, the induced currents

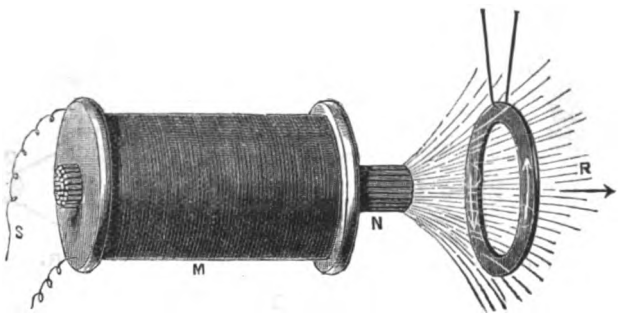

Fig. 4.

in the ring rise up and sink down in strength in exact synchronism with the changes in the inductive electromotive force acting on the ring. If the current flowing in the coils of the electro-magnet is represented as to changes in strength by a simple periodic curve, we may suppose that the magnetism of the core and the magnetic induction through the ring follow a similar law. It is very easy, then, to show that the induced electromotive force acting in the ring circuit, and hence the current in the ring, follows a similar law of fluctuation, but that the instant of maximum current in the ring coincides with the instant of reversal of magnetism in the electro-magnet. Under these circumstances we can represent the changing strength of the magnetic field in which the ring is immersed by a simple periodic curve m, and the changes of current strength in the ring circuit by another simple periodic curve c, shifted backwards relatively to the first by a quarter of a wave length (*see* Fig. 5).

By Ampère's law the force acting on the ring at any instant is proportional to the product of instantaneous value of the surrounding field and this current strength. If we multiply together the ordinates of these two curves m and c, and form a third curve p, whose

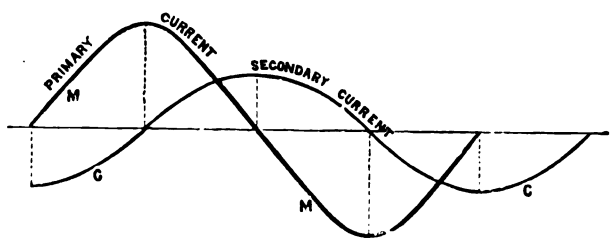

Fig. 5.

ordinate at every point is proportional to the product of the ordinates of the other curves (*see* Fig. 6) at those points, we obtain a curve which represents the fluctuation of force at every instant acting upon the ring. This curve p is also a wave-like curve, lying symmetrically above and below the horizontal line. The positive and negative areas of this curve included between the curve and the horizontal line represent the impulses or time integrals of the forces which act upon the ring. These impulses are alternately positive and negative. This is equivalent to saying that under the circumstances assumed the ring gets a series of small pushes and pulls, or repulsions and attractions, which succeed each other at the same rate as the changes of magnetic polarity of the magnet. The series of rapidly alternating and equal impulses would result in leaving the ring apparently unmoved. No real conducting ring can, however, behave in this fashion, because every real ring has a sensible "time-constant." Let us next see how the above state-

* On a "Magneto-Electric Phenomenon," By C. V. Boys, F.R.S. *Proc. Phys. Soc., London*, Vol. VI., p. 218.

ments will be modified if the ring has such a sensible self-induction that the current induced in the ring lags behind the inducing electromotive force in phase. Repeating the above construction for a force curve, on the assumption that the instant of maximum of the current in the ring occurs later than the instant of reversal of magnetism in the magnet, it is easy to see that the force curve consists now of two very unequal parts. It is not symmetrically situated with respect to the horizontal lines (*see* Fig. 7). The area of the hummocks (shaded portions) which lie above the datum line and which represent the repulsive impulses on the ring are much larger than the area of the hummocks below the datum line and which represent the attractive impulses acting on the ring. This means to say, that the ring when possessing self-induction experiences on the whole a repulsive force, or a series of repulsive impulses, when immersed in such an alternating magnetic field radiated from a

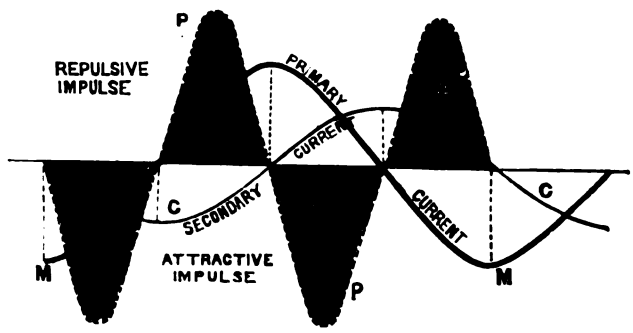

Fig. 6.

magnetic pole; and this repulsive force will be, within certain limits, more pronounced, other things being equal, the greater the time-constant of the circuit. You see clearly, therefore, that a ring or disc of copper in which the induced currents lag behind the inducing electromotive force in phase must experience a repulsive force when this inducing electromotive force is caused by a rapid flux backwards and forwards of lines of magnetic forces perforating through the ring or disc. The realisation of this inference in a striking manner is the first of a series of remarkable experiments on this subject due to Prof. Elihu Thomson. We have on the table an electro-magnet suitable for these experi-

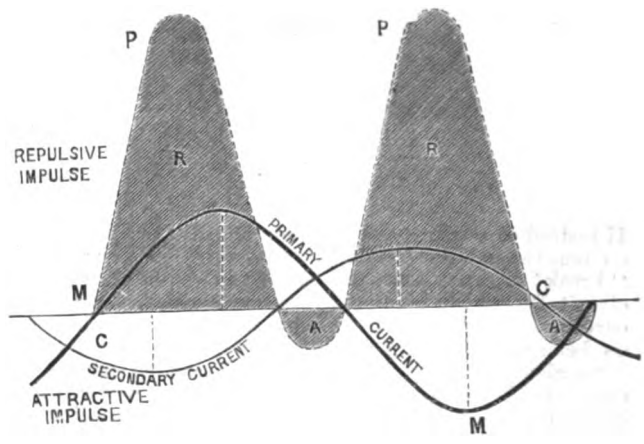

Fig. 7.

ments, which consists of a core of divided iron, surrounded by a coil in which I can cause to circulate a powerful alternating current of 40 to 50 amperes. Let us, however, begin with an experiment in which we employ a continuous current to energise the core. I give you, in Prof. Elihu Thomson's own words,* an account of this preliminary experiment: —

"In 1884, while preparing for the International Electrical Exhibition at Philadelphia, we had occasion to construct a large electro-magnet, the cores of which were about 6in. in diameter and about 20in. long. They were made of bundles of iron rod about $\frac{1}{16}$in. in diameter. When complete the magnet was energised by a current from a continuous-current dynamo, and it exhibited the usual powerful magnetic effects. It was found also that a disc of sheet copper of about $\frac{1}{16}$in. in thickness and 10in. in diameter, if dropped

* See the *Electrical World*, May, 1887, p. 258; or the *Electrical Engineer* (American), June, 1887, p. 211: "Novel Phenomena of Alternating Currents," by Elihu Thomson.

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flat against a pole of the magnet, would settle down softly upon it, being retarded by the development of currents in the disc, due to its movement in a strong magnetic field, and which currents were of opposite direction to those in the coils of the magnet. In fact, it was impossible to strike the magnet pole a sharp blow with the disc, even when the attempt was made by holding one edge of the disc in the hand and bringing it down forcibly towards the magnet. In attempting to raise the disc quickly off the pole a similar but opposite action of resistance to movement took place, showing the development of currents in the same direction as those in the coils of the magnet, and which currents, of course, would cause attraction as a result. The experiment could be tried in another way. Holding the sheet of copper by one edge, just over the magnet pole (*see* Fig. 8), the current in the magnet coils was cut off by shunting them. There was felt an attraction of the disc, or a dip towards the pole. The current was then put on by opening the shunting switch, and a repulsive action or lift of the disc was felt. The actions just described are what would be expected in such a case, for when attraction took place currents had been induced in the disc in the same direction as those in the magnet coils beneath it, and when repulsion took place the induced current in the disc was of opposite character or direction to that in the coils. Now let us imagine the current in the magnet coils to be not only cut off, but reversed back and forth. For the reasons just given we find that the disc is attracted and repelled alternately; for, whenever the currents induced in it are of the same direction with those in the inducing or magnet coil, attraction will ensue, and when they are opposite in direction, repulsion will be produced. Moreover, the repulsion will be produced when the current in the magnet coil is rising to a maximum in either direction, and attraction will

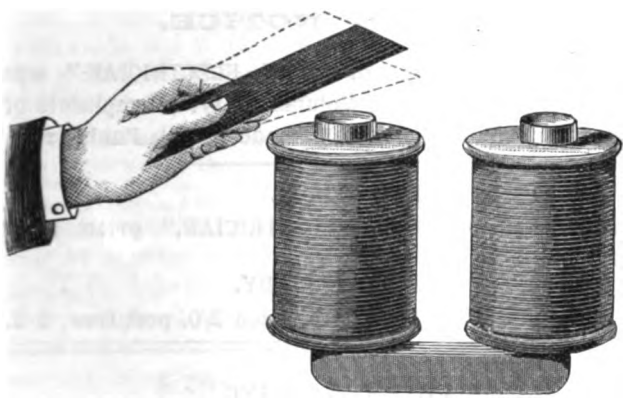


Fig. 8.

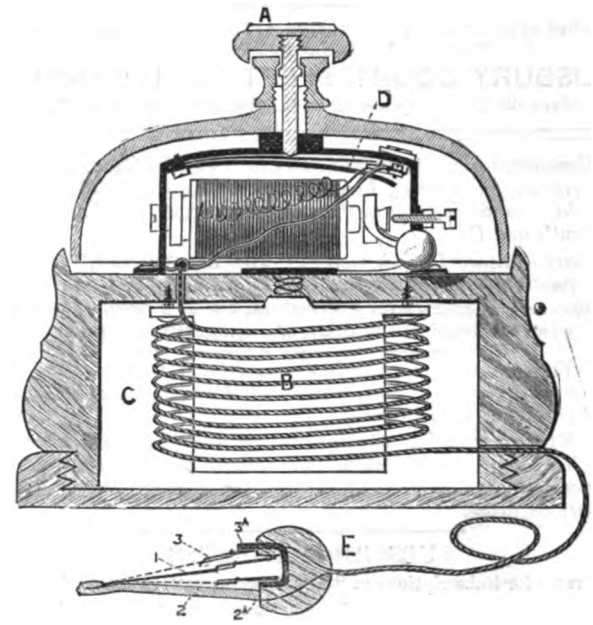
be the result when the current of either direction is falling to zero, since in the former case opposite currents are induced in the disc, in accordance with well-known laws; and in the latter case currents of the same direction will exist in the disc and the magnet coil. The disc might, of course, be replaced by a ring of copper or other good conductor, or by a closed coil of bare or insulated wire, or by a series of discs, rings or coils superposed, and the results would be the same."

(To be continued.)

PORTABLE ELECTRIC COMBINATION BELL.

The accompanying illustration is a section of an ingenious combined burglar and fire alarm, invalids' bell set and table call bell. The whole apparatus occupies no greater space than 3½ inches, and as the battery is a dry one it can be safely packed in portmanteau or travelling bag.

To use the apparatus as a burglar alarm, it is only necessary to detach the bottom of the case, uncoil the silk wire conductor C, and fix the contact press E to the door or window requiring protection, which, on being opened, will immediately start the alarm by releasing the spring, which flies back and makes contact at the *outer* projection 3A, the sliding tongue having previously been pushed back along the spring. The fire alarm can be adjusted to ring at any required degree above the normal temperature, and is constantly set. To enable a patient to communicate with another room, the contact press E, and as much of the cord as may be required, is taken out, and by pressing the spring, contact is made at 2A, and the bell rings. When in use as an ordinary call bell, the apparatus is placed on the table and the bell is rung by pressing the button A.



A, press for use as table bell; B, battery; C, flexible cord; D, fire alarm; E, double contact press, with sliding tongue on spring arm. 1, position when not in use; 2, making contact at 2A, for use as an ordinary press; 3, sliding tongue pushed back, allowing spring arm to fly up and make contact at 3A, for use as thief detector.

This compact little appliance is made by Messrs. E. J. Tumber and Co., of 4, Great Winchester-street, E.C.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, May 16th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: "On Huygen's Gearing in Illustration of Electric Induction." By Lord RAYLEIGH, F.R.S. "Dr. R. König's Researches on the Physical Basis of Music." By Prof. SILVANUS THOMPSON, D.Sc.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Photographic Image." By Professor RAPHAEL MELDOLA, F.R.S.

TUESDAY, May 20th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read with a view to discussion: "The Keswick Water-Power Electric Light Station." By Messrs. FAWCUS and COWAN, Assoc. MM. Inst. C.E.

WEDNESDAY, May 21st.

THE ELECTRO-HARMONIC SOCIETY.

4:30 p.m. Annual General Meeting, at 4. The Sanctuary Westminster.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting. Papers to be read:—"Rainfall of the Globe: Comparative, Chronological." By W. B. TRIPP, M.Inst.C.E.—"Mutual Influence of Two Pressure Plates upon each other, and Comparison of the Pressures upon small and large Plates." By W. H. DINES, B.A.—"On the Variations of Pressure caused by the Wind blowing across the Mouth of the Tube." By W. H. DINES, B.A.

ROYAL MICROSCOPICAL SOCIETY.

8 p.m. Paper to be read: "Micrometric Measurements with the Microscope." By E. M. NELSON.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting: "The Mannesmann Process for making Seamless Tubes." By J. G. GORDON.

THURSDAY, May 22nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Flame and Explosives." By Prof. DEWAR, M.A., F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. Paper not announced.

FRIDAY, May 23rd.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Manners and Customs of the Torres Straits Islanders." By Prof. A. C. HADDON, M.A.

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ELECTRIC TANNING.

For some years past the use of electricity as an agent for facilitating the processes of tanning has been progressing, through the usual stages of experiment and apparent failure, toward sound and practical success; though it is only quite recently that really solid results seem to have been attained. In this particular field of industrial application progress has been the more difficult because, of all the branches of applied chemistry, the art of tanning is, perhaps, the most empirical. The processes of the tanner are, for the most part, mere rule-of-thumb methods, to which little has been added for a century, save in the increased use of astringents prepared from foreign barks, such as mimosa and chestnut, as compared with the time-honoured use of astringents prepared from the bark of the oak. Raw hides are still fleshed, unhaired, and limed in accordance with ancient custom, and steeped for months in pits, the duration of the process depending on the nature and thickness of the hide and the quality of leather to be produced. All processes which take so long a time as from six to ten months for their completion are naturally carried on at a commercial disadvantage when compared with processes that can attain the same result in a shorter time. A greater capital is involved for an equal weekly output, and the fluctuations of price as between the raw materials and the finished product cannot be turned to advantage, if the process which transmutes the former into the latter requires many months, so readily as is the case if the process occupies but a few days. Hence, there

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have been many attempts to reduce the time required for tanning by the use of stronger extracts and astringents than the ordinary tan liquors. Most, if not all, of such processes have been condemned by the light of experience, as the leather produced rapidly by such means will not stand the test of wear or strain. The reason is simple. In the ordinary steeping processes of the tan-pit the hide is immersed in liquor which, as fast as it tans the surface, by that very fact renders the surface less permeable to the penetration of the liquor into the inner parts; hence the outer layers of the hide become tanned before the interior. This can readily be seen by taking a hide when but half tanned from the pit, and examining a section, when it will be seen that the middle of the section is still fleshy and whiteish, when already the exterior has become of the characteristic brown tint. This action is exaggerated when strong extracts are used in the pits, the exterior parts becoming over-tanned before the interior is half-tanned; brittle leather being the result. In face of the failure hitherto of all purely chemical modes of shortening the tanning process, it is not strange that throughout the entire tanning industry there should exist a violent prejudice against all rapid processes of whatever kind. But it is clear, from what has been said as to the cause of the failure of rapid processes, that if a means could be found to cause the tanning action to proceed simultaneously through all the layers of the hide at once, instead of attacking the outside first, and the inside afterwards, one of the strongest objections to the hastening of the process would have been removed.

As we understand it, this is indeed what is claimed to have been accomplished by the application of electric currents to the hides whilst they are being subjected to the action of the tan liquors. The notion is not altogether new. Various attempts have been made from time to time to apply electricity to tanning, amongst which that of the late M. Lucien Gaulard deserves some notice. In Gaulard's process the hide was placed in liquor between two parallel carbon plates, from one of which an electric current flowed to the other, the current being supplied from a continuous current dynamo machine. Skins stated to have been so tanned were, indeed, exhibited in England by Gaulard in 1888; but nothing came of the process, and it cannot be said to have proved successful.

In 1887, Messieurs Worms and Balé devised a process which differed in an important manner from that of Gaulard, inasmuch as another factor in the problem was introduced. It had been known in the tanning industry that if the hides, instead of hanging inert in the tan-pits, were subjected to mechanical motion, the penetration of the tan-liquor into the pores was facilitated; and some tanners had gone so far as even to place the hides and liquor in vessels to which motion was continuously imparted by machinery. This, of itself, to some extent accelerates the tanning action. The happy thought struck Worms and Balé that a combination of the two methods might give useful results. Accordingly, they devised apparatus for the simultaneous application of electricity and of mechanical movement, with results which far surpassed anything previously attained. Works were established near Paris which for eighteen months were in active operation, and then were removed into the city. Early last year a Company was formed in London to take up the Worms and Balé patents, under the name of the British Tanning Company; and during the time that has elapsed it has been steadily putting together the requisite plant for producing a large weekly output of leather. The Bermondsey works of the Company have this week been inspected by a considerable number of visitors. In these works the arrangements adopted are as follows: The raw hides are placed in large drums 11ft. 6in. in diameter, mounted so as to be capable of rotation, and fitted with internal electrodes to which connection is made through the bearings to a continuous-current dynamo machine. Each drum holds, as its charge, about half a ton of hides, and from two to two and a-half tons of liquor, the space inside the drum being about half filled. It is then set into slow regular rotation, and a current of electricity of about ten amperes is passed through it. The current is allowed to flow for a certain time and then cut off. The rotation is maintained for a time, which varies from two to six days, according to the thickness of the hides, which at the end of that time are found to be completely tanned, and are ready for the final currying processes. The liquor consists of an ordinary tanning extract, diluted to the required degree, to which a small percentage of oil of turpentine is added. It appears to be an open question as to which of the agencies employed the remarkable gain in time is due, no one of the means employed being alone able to produce the results. That the very small current density employed can so affect the molecular properties of the liquid as to enable it to penetrate the pores of the hides as rapidly as it does is a matter difficult to understand, and certainly cannot account for the whole of the results obtained. Neither can they be accounted for by the supposition that the electrolytic action of the current creates ozone or peroxide of hydrogen in quantities sufficient to alter the chemical operations to any great extent. Indeed, the part played by electricity in the process is still obscure. This much appears to be certain, that the tanning action goes on not at the surface only, but all through the substance of the hides at once; sections taken when the process is half complete showing no internal line of demarcation.

Another variety of tanning process, in which the hides are placed on rotating frames in a stationary vessel, through which electric currents are passed, has been patented by Mr. Groth, a former agent of the Worms and Balé process. As judicial proceedings are pending against Mr. Groth for infringement of legal rights, nothing can be said as to the relative merits of his process. In Sweden another electric tanning process has been at work for nearly two years in Nielson's tannery at Norrköping. The inventors of this process, Messrs. Landin and Abom, place the hides on wooden frames in a pit, with large copper electrodes at the sides; and they employ alternating currents of electricity. Their process, however, occupies forty-five days. It is claimed both for the Swedish leather and for that tanned in France and England by the more rapid process of Worms and Balé, that it is actually stronger than leather tanned by the old processes, and that there is a larger resultant weight of leather from a given weight of hides. With respect to the former point some statistics have been shown to us by Mr. Falkenstein, the manager of the Bermondsey Works, according to which the electrically tanned strap leather stands a tensile stress before breaking equivalent on the average to 4,305lb. per square inch; whereas strap leather tanned in the ordinary way gives on the average, according to the tests made by Kircaldy, only 3,572lb. per square inch. These figures point to a probable field of special usefulness for the electrically tanned leather for belting and other purposes where tensile stresses are to be transmitted. Whatever the merits of the individual processes, and whatever the ultimate scientific *rationale* of the facts may be, there seems now to be no question that electric tanning has got far beyond the experimental stage, and may be fairly included amongst the now numerous industrial applications of electricity.

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ON LIGHTNING-GUARDS FOR TELEGRAPHIC PURPOSES, AND ON THE PROTECTION OF CABLES FROM LIGHTNING,

With Observations on the Effect of Conducting Enclosures.*

BY DR. OLIVER J. LODGE, F.R.S.

In the Paper which I read before the Institution last year I spoke at length and showed some experiments on the subject of the protection of buildings from lightning; but although there were a few sections in that Paper, as ultimately printed, dealing with lightning protectors for telegraphic instruments and cables, yet time prevented my calling attention to this portion of the subject at the meeting, or of showing any experiments in connection with it.

The present communication may be regarded as a development of this omitted but important branch of the subject.

I do not know whether I shall escape controversy this time, but I have no wish to provoke it; and I wish entirely to avoid decrying the merits of other specific protectors in order to emphasise the advantages of my own. All I have to say on this head will have a quite general application, and amounts to about this: that whereas all protectors proceed on the admitted fact that the greater portion of a sudden flash prefers to jump an air space, rather than traverse a moderate length of wire, the cause of this well-known fact was but imperfectly appreciated—could not, indeed, be perfectly appreciated without recognising the rapid oscillatory character of sudden discharges, and the doctrine of impedance, or immense obstruction which good conducting wires offer to currents of this character; an impedance, it may be, of 100 or 1,000 ohms, whereas the resistance to steady currents may be but a ten-thousandth part of this amount.

In a word, the complete theory of lightning protectors has not till recently been known, and accordingly the many ingenious devices which are in use are naturally deficient in details which a completer recognition of theory would have suggested.

Long ago it was shown by the experiments of M. Guillemin and Prof. Hughes that existing lightning protectors were not perfect safeguards, inasmuch as they could not protect a fine wire from deflagration by a Leyden jar discharge. At the same time it was admitted by these experimenters, and is, I understand, a matter of common experience, that almost any lightning protector is better than none at all, and that the best of those in use are by no means inefficient instruments. They do not afford perfect security, but the occasions when they partially fail are perhaps not very numerous. It is, therefore, the practice to establish some sort of proportion between the elaborateness of the protector and the value of the apparatus to be guarded. In telephone exchanges a simple double comb is used. In telegraph offices a pair of plates finely adjusted close together is the form employed, while at cable stations the most elaborate kind of protectors, and often a number of different ones in combination, are arranged, because of the enormous interests at stake.

In electric light installations, on the other hand, it is customary, I believe, at present to use no protector at all. But I cannot suppose that this will much longer be regarded as a reasonable procedure. When one considers the extensive ramifications of conducting leads which are rapidly growing up, and the liability of the neighbourhood of house lightning-conductors to some portion of such ramification, it is apparent, I think, that lightning arresters are just as important for electric light leads as for telegraph wires. However, there is no need for me to emphasise this assertion, for I expect that before long a flash from somebody's lightning conductor getting into some electric light leads and burrowing underground throughout a district will do an amount of damage sufficient to eloquently call attention to the danger. At Peterhouse, Cambridge, lightning got at the gas engine, thence to the dynamo, and thence into the leads; where, I believe, it did little more than fuse a large number of cut-outs. But it is not likely always to spare the lamps in so considerate a manner; while danger of an altogether more disastrous kind can by no means be considered absent.

Returning from this digression to the telegraphic protectors at present in use, my contention is that, in all except the very simplest and crudest form of protector, a perception of the true conditions may lead to more complete protection without necessarily much increase in cost. And, proceeding to cases where cost is altogether a secondary consideration, and supposing it possible that telegraph engineers are fairly satisfied with the quality of the protection at present supplied to submarine cables, I would ask them (not pretending to know anything at first-hand about the matter) whether a number of obscure and unexplained faults do not develop themselves in the gutta percha of cables; whether it is not possible that some of these are due to electric waves of high potential which have got into the core and punctured its dielectric at previously weak spots; whether, indeed, such faults are not found occasionally to develop in the wake of a storm!

I would also point out the fact that a lightning switch is found damaged, or its wire, perhaps, fused by a flash, is no proof that it has entirely protected the cable from hostile influence. It shows that it has done the best it can; but since that best falls short of perfection, the damage to the protector, proving that there has been occasion for its activity, proves likewise that the cable has been in a position of danger, has received some proportion of the damaging current, and in all probability has suffered some amount of deterioration. The voltage which plays about in the very feeblest form of statical discharge is so enormously greater than anything ever developed by ordinary voltaic batteries, that one cannot regard with equanimity the entrance of any portion of such electromotive forces into the delicate vitals of a cable. Remember that a millimetre spark means 3,000 volts.

To illustrate by experiment the assertion I have virtually made—that no conceivable form of single air-gap, whether it be between knobs or points, or plates or wires, or between wire and tube, or coil and cylinder, or any other possible device, can possibly afford complete and adequate protection—I take the following simple instances:—

Experiment No. 1.—Arrange a small air-gap, as, for instance, between the knobs of a common "universal discharger;" connect the ends of a tangle or loop of thin covered wire, one on each side of the gap, and pass a Leyden jar discharge across it. The insulation of the thin wire is sparked through wherever two portions happen to come close enough together. [The wire actually employed had been the secondary of an old induction coil, and had been well soaked in paraffin.]

Experiment No. 2.—Diminish the air-gap until the knobs actually touch. The sparking at the crossings of the tangle are rather less bright and numerous than before, but they still frequently occur.

Experiment No. 3.—Instead of an air-gap, however short, use a foot or two of stout No. 0 copper wire or rod of highest conductivity, and shunt this with a thin wire tangle or coil. On passing a discharge along the rod, the crossings of the tangle sparkle as before, showing that the double insulation is still broken down.

These extremely simple observations establish the position I hold, that no ordinary protector can switch the whole of a flash out of a coil; for a solid copper rod, no matter how thick, is unable to do it, although such a shunt as that would divert every appreciable vestige of signalling or other useful current. The fact is that to sudden discharges the impedance of a short copper rod may run as high as 100 ohms; and if the discharge current while it lasts is 100 amperes, which is a very moderate value, then we see at once that the E.M.F. needed to drive the current through the rod is 10,000 volts, and this is, therefore, for an instant, the difference of potential between its ends. Such a difference of potential can leap three or four millimetres of air, and is amply sufficient to burst through the insulation of silk-covered wire several times over.

The particular mode adopted in these and such-like experiments for sending a Leyden jar discharge through the rod or across the air-gap is quite immaterial; any convenient plan serves, from simple hand-discharging tongs upwards. But, once more, I may say that the handiest method of working is to use a couple of jars, to connect their internal coatings with the terminals of an electrical machine, the distance apart of whose terminals regulates the energy of the discharge employed; and to connect the outer coats of the jars to the two ends of the rod, or to the two rods of the universal discharger, or to whatever the flash is wanted to pass through. Instead of a wire tangle or loop, which only typifies the coil of an instrument, and whose only advantage is that one has no compunction in spoiling it, I next proceed to employ an actual galvanometer, and take it as representing anything requiring protection, whether it be telegraph instrument or cable or electric light installation of any kind. A galvanometer serves pretty well, because it indicates whether any disturbing current passes round it or not. Notice, however, that it only indicates properly when the discharge really goes round the coil. If it jumps across insulation, and, still more, if it jumps from terminal to terminal, the needle indicates less or nothing. There are, in fact, two things to be aimed at and considered separately in the protection of instruments:—

First: the current has to be prevented from passing round the coil, and thus disturbing the magnetism of the needle.

Second: it has to be prevented from jumping across from layer to layer, and so damaging the insulation.

Conduction protection, and insulation protection: both must be attended to. To carry out both these protections completely is not easy; but I apprehend that the protection of the insulation from permanent damage is usually more important than the elimination of temporary disturbing currents which interfere with signalling and make the needle kick while they last.

* Paper read before the Institution of Electrical Engineers, on April 24, 1890.

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The galvanometer I use is a simple reflecting instrument, of a pattern devised by Prof. Stuart, at Cambridge, some time ago. A copper iron junction momentarily touched with the finger demonstrates that it is in a sensitive condition, and could easily be made to furnish its effective constant were it worth while. Connecting its terminals to the outsides of the pair of Leyden jars whose knobs are attached to the machine, separating the machine terminals about the fiftieth of an inch, and turning slowly, we see an attempted steady deflection representing the charging current, interrupted by a series of reverse kicks which occur at every minute discharge; though the sparks of any discharge such as is safe to send through the instrument are too faint to be heard.

Experiment No. 4.—Now insert between the wires leading to the galvanometer a sort of lightning-guard: a pair of plates mounted on a sliding arrangement, so that their distance can be varied (Fig. 1). Directly the plates approach within sparking distance, the galvanometer is apparently protected, and its kicks cease, even though by extending the machine terminals further the energy of the discharges be increased.

Interpolated Experiment No. 5.—Although not immediately important, a little fact may here be noted. If the plates of the guard are pushed still nearer together, or lightly pinched together, so as to leave only a microscopic interval, and almost to obliterate the existence of a spark between them, the needle of the galvanometer again begins to kick at every discharge; but this time wildly and irregularly, and sometimes in the reverse direction. Occasionally these disturbances are very strong, and the spot of light disappears; only to be recovered by tapping the instrument. At the instant when these kicks occur, the plates are momentarily short-circuited, as may be proved by replacing the galvanometer by a Léclanché

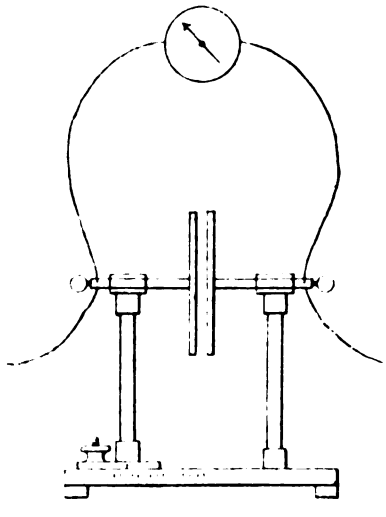

Fig. 1.

and electric bell. The bell is liable to ring at every discharge, and obviously for the same reason as the galvanometer kicks.

But whereas the bell only proves momentary conducting contact, the galvanometer proves this plus an electromotive force of occasionally uncertain direction and always uncertain magnitude. This E.M.F. would seem possibly to have something to do with the infinitesimal spark which temporarily connects the plates, and suggests an E.M.F. like the E.M.F. in an arc.*

* When I first came across this effect some weeks ago it was with tinfoil inserted between a pair of sparking terminals, and after the kick the tinfoil was often found fused on to one or other terminal. I therefore put it down to a thermal junction between tin and copper, caused and excited by the heat of the spark; and since it was a toss-up which side of the tinfoil adhered (being the side which made a just imperfect enough contact) the fluctuations of direction were easily accounted for; and by special trial this explanation was found to hold good. But then in this case after one kick the galvanometer was quiescent at subsequent discharges, until the tinfoil was disturbed sufficiently to break the fused contact again.

The experiment described in the text differs, in that there are no two metals, the metal is not fusible, the infinitesimal spark occurs between a pair of similar brass plates, or knobs, and the short-circuiting is quite temporary. I surmised, therefore, that it might possibly be a phenomenon of greater interest than a mere thermo-electric one. But after the reading of the present Paper, Prof. Hughes informed me that he had come across the very same effect, and had satisfied himself that it was only a thermo-electric one. I now think it possible that he is correct, and that the junction is caused by a momentary heat-pimple, after the fashion of a Trevelyan rocker or Gore's circular railway. And though this plausible explanation deprives the observation of any theoretical interest, I do not blot it out of the text, but leave it as a record in order to save the time of future experimenters who may easily come across the same thing

Returning now to Experiment 4, which illustrated the protection afforded to a galvanometer by a shunting air-gap, it is natural to ask how it can be reconciled with our previous observation, that protection by a single air-gap was impossible. But remember that complete protection involved two things, conduction-protection and insulation-protection; and the non-deflection of the needle merely shows that no important quantity of electricity now finds its way round the coil. But is the galvanometer therefore safe? By no means. Its insulation is in imminent danger, and if but moderately energetic flashes are employed we shall see sparks leaping across the coils or jumping from them to the metal work in a very pronounced manner.

Experiment No. 6.—As this is rather rough on the galvanometer, I prefer not to use strong flashes, but to show the existence of the tendency with smaller ones by arranging a safety valve or supplementary minute air-gap between the galvanometer terminals; said safety valve being either a couple of pins brought close together, or a chink cut across a narrow strip of tinfoil pasted on glass. The high electromotive forces which are endangering the insulation, and very likely already jumping in invisible places, can now demonstrate their existence by leaping this chink; and, no matter how the lightning-guard plates are arranged, it is impossible to check the little sparks occurring at the safety valve at every flash. Bringing the plates into absolute contact lessens the brightness of these sparks, but does not stop them; neither does replacing the plates by a solid bar of metal, as in Fig. 2.

But, directly the safety valve is employed to filter off and render manifest the residual effects left by a lightning-guard, the galvanometer needle begins to kick again whenever it acts; so that, singularly enough, whereas when no safety valve was employed the galvanometer appeared protected by the lightning switch, inasmuch as its needle is stationary, directly the safety valve is added and allowed to sparkle the needle kicks wildly with the very same flashes as before it ignored.

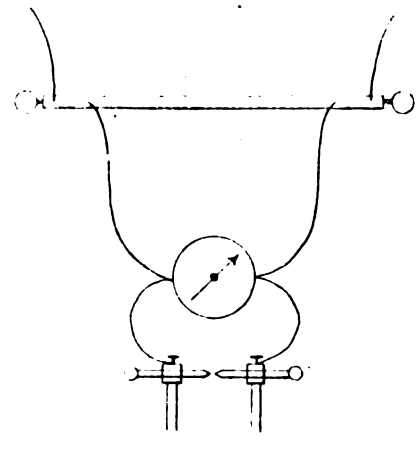

Fig. 2.

This behaviour appears to be mainly due to the same cause as produced the disturbance in the experiment interpolated above;* but it may be partly due to the weakening down of the flash by the safety valve so much that a residue of it is able to make its way round the coil, whereas it had previously been too strong, and preferred jumping across insulation in a manner ineffective for galvanometry. The possibility of the occasional truth of this latter explanation is by no means to be overlooked. It often happens that an unprotected galvanometer has its needle less strongly affected by sparks say an eighth of an inch long, than by sparks the fiftieth of an inch long; but the reason obviously is that the more violent discharges are not really passing round the coil, but are taking all manner of short cuts.

Experiment No. 7.—Instead of employing a rigged-up model of a protector, for the purpose of calling attention to principles, an actual lightning-guard may of course be used, and its behaviour studied in detail. I take, as an actual instance, a Saunders' protector, so much employed in connection with submarine cables. Its essential part is a fine wire, through which the useful currents have to pass, surrounded by an earth tube with points protruding towards the thin wire, which is stretched by a spring along its axis. The idea is that the tube will relieve the wire of dangerously high potential, while the wire itself will fuse if dangerously strong currents try to pass along it. A supplementary device is a short-circuiting contact, whereby a spring puts the cable to earth directly the wire is fused or in any other way broken. The diagram (Fig. 3)

* I do not feel quite certain of the sufficiency of Prof. Hughes' thermo-electric explanation

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sufficiently represents the instrument. A Jamieson protector is a neat arrangement, involving a fine wire as well as an air-gap; there is also some wire coiled on a metal cylinder, but the metal deprives it of all appreciable self-induction.

If I now send very small discharges down the line wire towards a galvanometer protected by this Saunders' guard, they will, if small enough, escape it and pass through the galvanometer, either exciting its safety valve or disturbing its needle or both. But if stronger flashes are sent, the protector begins to act, sparks are seen between fine wire and surrounding tube, and the galvanometer disturbances diminish as already explained; but those at the safety valve never wholly cease. One is not to suppose that the bigger the flash the less the effect; that would be a very desirable but somewhat impossible conjuncture. The smallest effect is got with the weakest flash, which is just sufficient to spark to the protecting tube. Anything stronger or anything not greatly weaker than this gives larger effects.

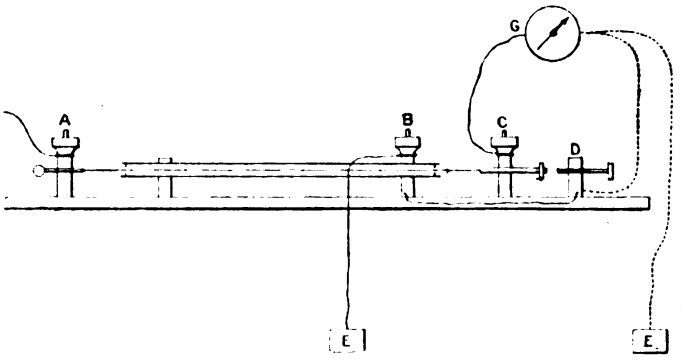

FIG. 3.

The fine wire part of this guard is a good feature and one that may be advantageously introduced into any protector, on the principle of a safety-fuse or cut-out, to eliminate steady or slowly varying currents of too great strength. But the short-circuiting of the protected terminal to earth by the terminal D as soon as the wire is destroyed, is, perhaps, not an unmixed good, for a subsequent earth-seeking disturbance has then two paths between which it may divide—if the connections are made as in Fig. 3—one along the intended earth-wire, and the other through the instrument intended to be protected.

True, this latter is a much longer route, but not so infinitely longer that it need convey none; especially if a few short cuts across insulation can be taken.

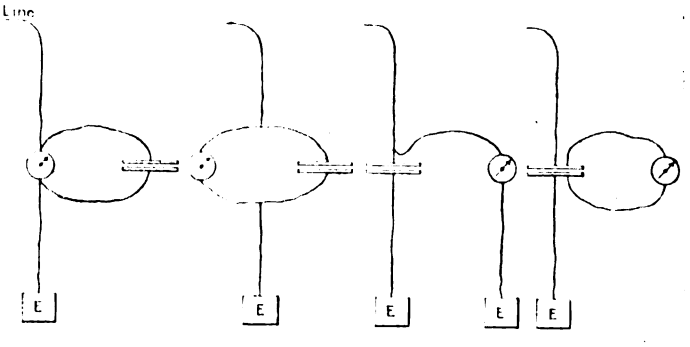

FIG. 4. FIG. 5. FIG. 6. FIG. 7.

We see at any rate how important it is to make the earth lead as short and direct as possible, and how it is better to connect the thing to be protected to the two binding screws C and D of the instrument as indicated by the dotted line, rather than to make an independent earth.* If, for instance, a cable be joined inside to C, outside to B or D, the spring short-circuiting is all good, the only objection being that however prompt the spring may be there is ample time for damage before the contact can be made.

The statement concerning the importance of a short and direct earth also applies to the desirable mode of connecting up lightning-guards in general. They should always be inserted direct into the line circuit between line and earth, never be simply led up to by side wires.

Thus, of the three modes of connecting a plate or other lightning protector to a telegraph instrument, Fig. 4 is an altogether bad mode; Fig. 5 is but little better; Fig. 6 is the same thing, or even worse; while Fig. 7 is a thoroughly good way. As I have said so often, even this is not perfection, but it is quite the best that can be done with a single air-gap of whatever kind.

Throw the leads into the protected circuit; let nothing interfere with direct connection of lightning switch to line and earth respectively, and do not use an independent earth for your instrument's earth terminal. The time taken for a disturbance to travel even a foot of copper wire is by no means to be despised, notwithstanding that it travels with the speed of light; and the impedance of every inch tells.

(To be continued.)

* The dotted line connection in Fig. 3 is the most favourable possible, and it was the one used at the meeting. It is far better than an independent earth for the galvanometer terminal.

ELECTRIC TRACTION DATA.

The following is a full report of the discussion on Mr. A. Reckenzaun's Paper:—

Mr. ALBION T. SNELL said that Mr. Reckenzaun's very interesting Paper was so teeming with notes, figures, and information, that one had hardly the time to grasp it; and therefore he felt scarcely able to do justice to it. He had not expected the author to have spoken so much about traction, pure and simple; he had, indeed, expected that Mr. Reckenzaun would have given a great deal more data about accumulator cars, about gearing, about motors, and so on. He was connected with the Electric Traction Company, in conjunction with his friend Mr. Fraser, and had been making experiments with accumulator cars for some five or six years. He had made a few notes before attending the meeting with a view of speaking on them, but as Mr. Fraser was present he would not go very closely into the details; he would merely deal with them in a rough way, and leave Mr. Fraser, who had had entire charge of the tramcar department for the last three or four years, to deal with the details. They had at Barking six cars, one of them in reserve, and they made on an average about 250 car miles per day. Their coal consumption was about one ton per day; their traction averaged between 20lb. and 30lb., which was almost identical with the figure given by Mr. Reckenzaun. The electrical horse-power per hour per car mile was, as near as could be, one. That also, he thought, agreed with the figure given in the Paper. He had had to do very largely with electrical traction under other conditions; he had had to haul by means of moving ropes in collieries, and also to work by means of locomotives on colliery rails. There they had to deal with a different state of affairs altogether. The rails in collieries were by no means so good as those which were used on tram lines; they were of a different character. The most common form of rail in collieries was the bridge rail. Another form, which was worse still, was the T rail. Then there was the ordinary one, which they knew so well. In designing a plant to work on such rails, where the traction often reached as much as 70lbs. a ton, it was necessary to make experiments to ascertain as near as possible what the traction would be for each particular case before they designed the plant. He had used the following equation for determining the manner in which the horse-power would be spent—

$$\text{H.-P.} = \frac{W\,K\,N}{33{,}000} + \frac{W\,2.240\,N}{33.000}\sin\theta.$$

They would see the importance of using it when they considered the high value of the resistance. W was the weight in tons of the total load; K was the resistance to motion, including the friction of the tub axles; N was the speed in feet per minute, and θ was the angle of the inclination which they were working on. If they were pulling a load up hill they would have to use the positive sign. If they were going down hill the chances were that the load would tend to gravitate. Then, the second term of the right-hand side of the equation might be greater than the first term. When he first entered upon this class of work he imagined that K would probably assume the proportions of about 40 to 50; but on making experiments by means of dynamometers, that is to say, putting the car on as level a piece of rail as he could get, placing the dynamometer in the rope and hauling it slowly, he found on taking measurements that the value of the coefficient of resistance averaged 70 on lines of the best type, that is with the bridge or vignole rails; but that it would rise as high as 100 even on T rails, or other rails worn flat. So that the first term of the equation might under certain conditions assume relatively large proportions. This high value of K was due primarily to dirt on the rails and the friction of the tub axles. He had known the value to be so high in some cases that the load would not gravitate on an incline of 1 in 12. Of course, in tramcars they had not to deal with such conditions as these. The ordinary sunk rail was very different indeed. At Liverpool, he believed they used the centre flange wheels with sunk rails. He had no data himself as to the resistance, but he took it that the friction would be more than that of the ordinary rails used in London or on the other tram lines. He must congratulate the O. S. A. on the very important Paper laid before it. The curves prepared so carefully by Mr. Reckenzaun were most valuable.

Mr. FRASER said that with regard to coefficient of friction on tramcars, on lines of all sorts, and with all possible conditions, according to the weather, to the extent of scooping, of cleaning, watering, &c., he found from a very considerable experience that, as Mr. Reckenzaun said, it varied between 8 and 12 per 1,000. Ten would be 24lb. to the ton, but if he gave the coefficient in percentages, it would be found good for every possible system of weights and measures, or any arrangements they might choose

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to make. The difficulty concerning the state of the track, unfortunately, was not entirely in the hands of the electrical engineers; it was much more in the hands of the Tramway Companies; they did not all of them go to the trouble either to have the roads well scooped and well cleaned, nor, above all (and Mr. Reckenzaun drew particular attention to that point), to have them well watered. Liverpool, indeed, was the only place he knew of where the track was constantly watered. That was an immense advantage, as had already been pointed out, and therefore it was not necessary for him to do more than corroborate the statement. As regards the value of the coefficient of traction, which varies from 8 to 12 per 1,000, it was necessary to take very closely into account the particular vehicle with which they were dealing. For instance, in the Newry-Bessbrook coefficients, which were mentioned in the Paper varying from 27 to 30, if he remembered rightly they referred to different trains; that is to say, in one case it would, perhaps, be a locomotive vehicle pulling another car, or two cars behind it, the total weight being so much, and in another instance it would, perhaps, be the locomotive vehicle alone simply propelling itself. Now, if those coefficients of traction were taken as they were, he believed in that case from the power exerted in taking the car over the line; and in taking a train of 1, 2, or 3 cars, they would get different coefficients of traction in each instance—erroneously, because the power which would be taken to move a locomotive car would not only include that of its own actual weight, but also the work consumed by giving motion to the moving parts of the car, which, properly speaking, should be taken into account, but in the proper place. As far as the work required to move one vehicle or more over any possible line, of course the equation Mr. Snell had put upon the black board explained all; but perhaps he might be permitted to put it in the way in which he was accustomed to use it, and which seemed much simpler. His formula was

$$W = (f \pm x)\, p\, d$$

W represented work, f the coefficient of traction, x the gradient, p the weight of the loaded car, and d the distance. One great difficulty that they had to contend with in doing this kind of work was the immense opposition offered by all horsey people connected with the ordinary tramcars. Such people did their utmost to put the thing back; and wherever an electrical engineer might go and attempt to establish electrical traction, he might rest assured that he would meet with that opposition developed to its maximum point. It had been said sometimes by high authorities that electric traction could certainly be done—it had been done twenty years ago, but that was an incorrect statement. The fact is that it had not been done, and that only a few had worked it out, and those few who had worked upon it could be counted upon the fingers of one hand. It was first necessary, it seemed to him, to prove that the thing could be done at all in a way which would give every satisfaction to the tramway companies and to their passengers, quite independently of the commercial side of the question. The commercial side must necessarily be treated in the end; but until everything was done to the satisfaction of all concerned the commercial point could very well be left out of the question.

Mr. ESSON said he was very pleased with the excellent Paper which had been read. These experiments on traction were very interesting and very instructive. In the Paper by Dr. Louis Bell, referred to by Mr. Reckenzaun, he mentioned that generally speaking the reports published on electric traction were models of how to avoid giving information; but he thought, as far as Mr. Reckenzaun's Paper was concerned, that that accusation could not be made against it. The question of cost had not been gone into by Mr. Reckenzaun; and with their permission he would make a few remarks on that interesting question, for, after all, in this mercenary age, it came mostly to a question of how it would pay. The total cost of tramway working in London varied from 10¼d. to 7d. per car mile, the usual being 9d. or 10d. Of the several companies, some paid a dividend of 9½ per cent., some 9, some 2, some 1 per cent., and some paid nothing at all. In London the tramways which cost most to run paid the highest dividends; and the very cheapest tramway they had in that district, which was the Croydon Tramway, only cost 6·71d. per car mile, and in 1888 it had to make up a loss of £281. On the Continent the cost per car mile was cheaper. In Gottenburg it was 5·57d.; in the German Union it was 6·82d.; and in Bremen it was 4·44d., so that on the Continent the cost of running per car mile was considerably less than it was in this country. When they looked at a tramway company like the North Metropolitan, with its capital of something over a million sterling, and its 40 miles of rails, having a total annual expenditure of nearly a quarter of a million, it would be found that a penny saved per car mile meant something like a total gain per annum of £25,000. In the case of a tramway which was not paying, the gain of a penny per car mile meant the beginning of a very respectable dividend to the shareholders; so that electricians and electrical engineers had everything to encourage them in endeavouring to reduce the working cost of the tramways in the Metropolitan District. A large amount of these charges, of course, belonged to fixed charges, such as office and staff expenses, maintenance and renewals, of the line, buildings, &c. He had run out the cost as nearly as possible of what the actual haulage of the cars amounted to. In the first place, for each car they had nine horses; and taking the value of a horse and his harness at about £50, the nine horses cost £450, or, taking his useful life at three years, £150 per annum. That meant something like £3 per week. Now the keep of a horse costs about 15s. per week, that came to £6. 15s., and, with attendance and so on the cost of horsing per car might be taken at about £12 per week, or 35s. per day. If they took 80 car miles as about the running per day, that came to something like 5d. per car mile, so that they had got 5d. for actual haulage for the motive power, as it were, to work the cars. Electricians had to compete against this; they had to cut down the expenses by their electrical locomotives, or their motors, or whatever they were, and they had to reduce this cost of 5d. This was what they had to guide them. It was very difficult to get the cost of steam tramways, because in this country the tramways which employed steam power generally worked with horse-power as well, so that the figures got mixed and there was considerable difficulty in analysing them, and even if they had the cost of steam tramways for a particular district it would not form a very fair comparison for the working of steam traction in another district, the conditions varying so greatly for different lines. Generally, however, the steam trams were not much lower than horse trams, so that steam up to the present had not been able to make any considerable reduction in the cost of running tramways per car mile. The lowest cost in this country at the present time is the North Staffordshire Steam Tramway Company, whose cost of running per car mile was 8·71d. Now, the conditions upon which electric traction companies were allowed to work tramcars were of a very onerous character. As Mr. Fraser very properly said, all sorts of objections were thrown in their way by the horsey people, and they had to fight a very severe battle before they could run their cars upon their lines. Of course the tramway companies' way of looking at the matter was quite rational. They said, "Here is all our rolling stock; we have so many cars, and they cost £170 or thereabouts. You must not alter our cars and make them accumulator cars, because your system may break down, and then all our cars may be destroyed." That is the first thing they said; and then, "You can take out our horses, and you can pull our cars by electricity or anything you like; but you must do it in such a way that you do not interfere at all with our lines." So that the fact is, either the electrical companies have to take the cars off their lines and substitute electrical cars, taking the loss; or else they have to do, what seemed to him to be a more natural plan under the circumstances, they had to construct electrical locomotives and haul the ordinary cars. Some years ago Mr. Elieson tried this on his Stratford line, and though the scheme does not look very rosy at the moment, some valuable information was gained during the experiments made on that line. He (Mr. Esson) tested the traction, and found that on the level parts of the line, from Stratford Church to the "Princess Alice," in the Romford-road, it only amounted to 20lb. per ton, which was very low. The line, he supposed, being new and everything in first-class condition, made the coefficient somewhat lower than Mr. Reckenzaun thought the average would be. Then, as to Mr. Fraser's remark, that the traction on the line he had to deal with was 12 per thousand, which amounts to 27lb. per ton--

Mr. FRASER: Eight to 12 per thousand.

Mr. ESSON: Twelve per thousand is the highest.

Mr. FRASER: Eight per thousand would give precisely the 20lb. you have mentioned in this instance.

Mr. ESSON: Eight to 12 per thousand. The Canning Town section is, then, very similar to the Stratford section. He would like to ask Mr. Reckenzaun what sort of dynamometer he used for making his tests. As a matter of fact they had found it rather difficult to use dynamometers. He had put in an ordinary spring dynamometer between the draw bars at the end of the car, but there was a temporary inconvenience. The first time they put in the dynamometer the engine backed, and it was smashed. The second time, however, they had taken their precautions, and they got a somewhat rough result which gave, as he said, 20lb. per ton. They had not gone very far with those experiments, but he had intended later on, if he had the opportunity, to measure the power by a hydraulic dynamometer. He should like to know whether Mr. Reckenzaun had tried that. The weight of the Elieson locomotive and the car, loaded, was about eleven tons, and they used six electrical horse-power to give them a speed on the level of eight miles per hour. That was done over and over again. Well, the locomotive weight in that particular case was considerably more than was necessary; and a properly-designed locomotive, with its accumulators, car and all, need not have a greater weight than ten tons, on which they would put a motor taking an average of six electrical horse-power. As to the cost, such an engine, with its motor and gearing, and a double set of accumulators, would cost £620. Out of that there was £300 for a double set of accumulators—that was £150 each set—so that they had £320 for the motor, the car, and the gearing; and they had £300 more for the accumulators. Then they required for the generating station to charge the accumulators, 10 horse-power indicated per car, so that the amount of capital required to provide a generating station, engines, dynamos, and boilers, came to £150 per car. Altogether they had as a total £770. Taking 10 per cent. on £470, they had for renewal and maintenance and depreciation £47 per annum. Then they took 25 per cent. on £300, that was for the accumulators, and that came to £75, which made the total of £122 per annum; or, say, 7s. per day, required for depreciation and renewals. The coal used should not exceed 4 cwt. per car per day. Taking the oil and the coal together, it amounted to 5s. per day, so that they had altogether 12s. per car per day. This amount was about one-third of what horse traction came to. Providing for all contingencies whatever, the cost of traction by electricity should be very much less than horse traction, the profit on the running giving a considerably increased dividend on the larger capital required.. It was a very regrettable fact that up to the present time they had had very little chance of proving it experimentally. Tests had been made in America. In America, of course, the conditions were different from the conditions here. They had in England to work in crowded streets, and they had no overhead railways as in America. Well, in 1887 out of all the electrical railways in America, only two had the conduit rail, or a sunk rail—all the others were overhead. He need scarcely say that as regarded the cost of working, inasmuch as keeping the rails clean affect it, the overhead line had an immense advantage. Taking the very worst possible case, taking all possible contingencies into account, there seemed to be a very decided advantage in electric traction. The only pity was that they could not have some strong company to take up the thing in a

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business way, and to work it on a large scale. He was afraid that very soon, if some of the larger companies did not wake up, the Americans would step in. Perhaps Mr. Sprague would have to show them how to do it!

Dr. THOMPSON said they had all of them to thank Mr. Reckenzaun for his most useful and informing Paper. When they had the opportunity of getting it in printed form no doubt they would keep it by them ever afterwards as a piece of standard literature on this subject. He had worked so little on the question of traction that he felt perfectly incompetent either to criticise or seriously to enter into the discussion of the immediate subject of the Paper; he could only express his admiration at the pains which had been taken to get at the facts in these experiments. Reference had been made to the running of cars electrically some years ago by Mr. Elieson on the North Metropolitan line to Stratford. Mr. Esson had referred to that scheme—it was something more than an experiment—that experience as having come to an untimely end. No one regretted that more than he did, for he took great interest in the Stratford line. If they examined into the circumstances of the case they would see that it was not electricity that ought to be blamed for the untimely end to which that experience came. As long as Mr. Elieson was in charge of those cars they ran extremely well, and they had very few troubles of any sort whatever; but the thing went out of his hands and passed into the hands of another firm of engineers—engineers, mind. They were supposed to be competent engineers; and lo and behold, the very first day they took the management of the thing they spoilt two engines by running them over points, the points being so misarranged that the two wheels took two separate lines and branched out one from the other (laughter). They also managed to ruin another engine by tearing the teeth out of the driving arrangements. Hornbeam teeth, properly set, ought not to have come to grief. It was a purely mechanical breakdown, due partly to the fact that the people who were running the cars did not understand, and had not taken pains to master, one very simple electrical arrangement which Mr. Elieson had introduced. Mr. Elieson had introduced a second switch to turn on a small current for the starting up of his motor before he threw it into gear. Then he had a big switch to turn on the big driving current. "Well," they said, "this is unnecessary—we will have one switch only which would be simpler to manage, and we will have the big switch." They put on the whole of the current, and got an enormous speed on the motor, and then ran it into gear, and the first time it was put into gear off went the teeth of the gear. Purely a mechanical break-down, not an electrical thing at all. A system which had worked excellently for nine months of experimental trial under Mr. Elieson broke down in three days when the working was given over to the contracting firm of engineers! When people said electricity did not do for driving tramcars, and pointed to the North Metropolitan failure in support of their argument, they had simply to remember that it was not an electrical breakdown at all; it was a purely mechanical one, which good engineering might have avoided. It was perfectly clear to everyone who had gone into statistics, and they had had a large dose of them, thanks to Mr. Esson, that the cost of *electrage* was a great deal less than the cost of *horsage* for cars; and the sooner that was brought to the minds of directors of tramcar companies the better it would be for them all. If directors could only be assured point blank that it was to their interest to turn out the horses and put in the electric motors, they would do it in the hope of earning bigger dividends, and of having the honour and glory of being the first people in this country to run electric tramcars successfully. One point he would certainly like to have heard more upon from Mr. Reckenzaun was the question of driving gear in the motors. The author had had so much experience of so many different kinds of gearing, that probably he had an opinion well settled, and consequently worth learning, as to what was the best kind of driving gear. Lastly, he would like to express his admiration of those diagrams, and of the patience which that man must have had who had to look at the ammeter during all that time. He put it to Mr. Reckenzaun whether it would not be worth while for this purpose, if for no other, to devise some kind of recording ammeter, which would take down the record minute by minute, instead of having to keep that sagacious individual on the watch. There were some recording ammeters now, but they were not very satisfactory for putting behind the tramcar. There were some little things made by Richard, of Paris; but they were not very satisfactory things, certainly not very satisfactory if they were to be put on behind a vehicle which would have to go bumping more or less over an uneven track.

Dr. SUMPNER said that recently in one of the American periodicals Mr. Hutchinson, of the Sprague Company, had published several figures showing the relation between the expenses on five lines in different cities of America driven electrically by the Sprague Company, but not driven by accumulators. The absolute cost was not given, only the relative cost. One item was the cost of carmen, which he assumed included not only the cost of the men employed on the cars, but the ordinary office expenses. Another item was the cost of maintenance of the line, and the cost of the driving power was put down as a third item. On a very steep line, grading 6 per cent., the cost of the carmen came to 71·5 per cent., the cost of the maintenance of the line to 1·8 per cent., and the cost of the electrical power to 26·7. On a line, which on the whole was a level line, the cost of carmen only came to 67 per cent., the maintenance was 18, and the cost of the electrical power 15. On another line, also level, the cost of the carmen was 65·5, maintenance 12·7, and electrical power 21·8. The mean result from all the five lines was: cost of carmen, 69·5; maintenance, 11·5; and electrical power, 19 per cent. Till he had seen those figures he had no idea that the cost of the electrical power bore such a small proportion to the entire cost of the line. In the item of electrical power was included labour, fuel, oil, and waste. The 19 per cent. was made up of 11 per cent. labour, 6·3 fuel, and oil and waste 1·7; so that the cost of the fuel only came practically to 8 per cent. of the whole, whereas Mr. Reckenzaun stated that the traction expenses on horse tramways came to about two-thirds of the working expenses of the line. No doubt, however, that item of traction expenses included some of the things that he had just put down in the cost of carmen, and he would like the author of the Paper to give fuller information on the point. The small ratio of the traction expenses to the whole would prevent existing companies from changing their system, while it would render new companies less reluctant to adopt electric traction.

Mr. RECKENZAUN, in reply, said that Mr. Snell had given them very useful information, and that the formula which he had mentioned had been published before. Mr. Fraser made one very serious remark; he said that the commercial point could be left out of the question. Now, in his opinion, that really was the first question, for unless electrical traction was very much cheaper than horse traction it was no use experimenting with it, or spending money, or time, or brains upon it. He was perfectly convinced that electrical traction was very much cheaper than horse traction, and the first thing to do was to show that practically it was. Mr. Esson went through a long series of figures with regard to traction cost on the various Metropolitan tramways. He himself had gone through those figures year after year for the last seven years, and he knew most of them, but he did not propose to go into them then—because, first, he had not time to cover so large a field; and, secondly, he read a Paper before the Society of Arts about three years ago, which covered the ground very largely. Of course, since then much more had been done. Mr. Esson was right in saying that the conditions in America were very different from what they were here. In this country one of the greatest drawbacks to electric traction, or any other traction—even horse traction—on tramways was the public authority. It took many years to introduce tramways in England after they had been a perfect success in the United States and other countries. Six years ago when he wanted to run cars experimentally on one of the lines in London, he had first to obtain the permission of the Board of Trade. Major-General Hutchinson came twice to see the car, and to judge whether it was perfectly safe to use in the public streets. Then, after two or three months' delay, he got permission from the vestries to run a car for a few days on the line, and he did run it; but there it ended. He was not a rich man, and he had no financial support. He did not get the support of the tramway company. They said, "You can run all our cars at your own expense on our lines, if you like; but the first thing you must have before you can run electric cars on our line is an Act of Parliament. An Act of Parliament will cost you from £1,000 to £2,000—we do not know exactly—and it will take a year or two to get it." That was the sort of thing people had to contend with in this country when they desired to introduce electric traction. The Americans could do just as they liked. He did not say that was an advantage, but he thought it had shown itself to be an advantage, because there were now over 1,000 miles of electric railways in the United States, carrying from six to seven hundred cars, and there were as many more at the present time in course of construction. Mr. Esson had asked what sort of a dynamometer he used. He had not used any dynamometer. The cars he experimented with were all self-contained cars, and they did not draw anything else behind them, so the dynamometer they used was an ammeter, and he assured them that it was the most delicate and the most accurate dynamometer they could use. He was not going into the cost of electric traction, nor into the question as to the adoption of accumulators. That was also a separate subject which he had dealt with on various previous occasions. The great question which Dr. Thompson gave him was on the best kind of gearing to be used. On this subject also he had read a long Paper before the American Institute of Electrical Engineers about two years ago, which turned exclusively on gearing for tramways. There he had enumerated the numerous experiments which had been made in chain gearing, spur gearing, friction gearing, rope gearing, and worm gearing. That question was not quite decided yet, and it was a very difficult question. Spur gearing was very economical, but noisy, and very objectionable on account of the noise. Chain gearing was very troublesome, because the distance between the centres of the driving wheels and the driven wheel was necessarily short, and there was no elasticity in the system, so that when there was a slight expansion, or, perhaps, he should say elongation of the chain, there was always a danger of a link of the chain riding over a tooth, and breaking the chain to pieces. With a long chain there was a certain amount of slack, which took up a small amount of expansion; and chain gearing had been very troublesome on that account. It was also noisy. He used a worm gearing, as everybody knew, of a special design, which gave very great satisfaction; it was not quite so efficient as spur gearing, for instance; but it was very durable and silent. With regard to Dr. Thompson's suggestion that there ought to have been some device for automatically recording the readings, that would have been a very useful thing. On one occasion they made two trips of seven miles each, in the course of 2¼ hours, and he took every reading himself. He assured them he was perfectly crippled; he stood in one particular position the whole time, doing nothing but writing down figures at a given speed ratio. Until he had drawn out the diagrams within the last few days, he had not himself been aware that there were such enormous variations in the tractive force. Dr. Sumpner was surprised at the relative expenses of men, maintenance of line, and cost of driving power in the United States. He need not be surprised if he knew that the car-drivers and the conductors get $2½ a day wages—those were the lowest wages, for in the Western States they got as much as $3 a day, and the wages of the men at the central stations were similarly high. The only way in which he could explain the figures given by Dr. Sumpner was, that the men's wages being so high they formed a large percentage in the total cost.

A vote of thanks was then accorded to Mr. Reckenzaun for his Paper, and the meeting terminated.

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THE RAILWAY RATES INQUIRY.

FRIDAY, May 9th.

Lord BALFOUR OF BURLEIGH said that the Court had received an application from the Postmaster-General to be heard in reference to the classification of certain articles.

Mr. STUART, of the Post Office, said the articles in regard to the classification of which the defendant objected were "telegraph poles," "insulators," "copper wire," "bare copper wire," and "copper wire covered with gutta percha."

Lord BALFOUR OF BURLEIGH said the Post Office did not seem to be aware that written objections and the reasons for them ought to have been lodged in order that they might be heard as each article was reached. The articles mentioned by Mr. Stuart had already been passed, and it would be inconvenient to go back to them, especially as the Court had received no written objection or reply from the railway companies. He thought the best course would be for the Post Office to send in written objections, stating where they wished these articles to be classed, and why. Their communication would then be sent to the railway companies for their reply, and the Court would then fix a subsequent day for dealing with the matter.

Mr. COURTENAY BOYLE remarked that in his official letter the Postmaster-General assigned no reasons whatever for his objections, but simply said that certain articles ought to go into a lower class.

SATURDAY, May 10th.

Class 3 was again under consideration.

Dynamos and Electrical Machinery not Packed.

Mr. TROTTER said the objectors were satisfied with the companies' proposals.

Electric Cables.

Mr. TROTTER said he appeared to uphold the objection to the classification of this article. The phraseology of the railway companies was literally identical with that of the telegraph cables, which they said were included in the term "electric cables." There appeared to be a remarkable impression about the way in which cables were sent. They were a comparatively new article of manufacture, rapidly increasing, and of decreasing value. He had made careful inquiries of almost the whole of the electrical trade, and the very suggestion "that frequently the cable has to be coiled on to the waggons, and uncoiled for delivery," had never been heard of, and had caused considerable amusement. The makers had never heard of such an instance, and he challenged the railway companies to give him a single instance where a cable had been sent in this manner. As to the same objection being applied to telegraph cable, he had applied to a gentleman who was undeniably the highest authority—Mr. Preece, of the Post Office—and to other engineers in H.M.'s Post Office, and he found, in the course of Mr. Preece's 38 years' experience, there were only three cases that he could remember in which a submarine cable had been loosely coiled on to the trucks, in cases of extreme urgency, where they were compelled to do it; and he has had experience of 118 submarine cables for telegraph purposes. Submarine cables were sent naturally by ship; they were loaded on board cable ships, and they were very rarely sent by rail.

Lord BALFOUR OF BURLEIGH: How are they carried on the railway?

Mr. TROTTER: In these three instances I believe the Post Office would tell you they were loaded most carefully by the Post Office officials on trucks, and taken off again by them in long lengths and "shore ends," a heavy armoured cable. Those are the only three cases I can hear of.

Lord BALFOUR OF BURLEIGH: In those cases they were specially loaded?

Mr. TROTTER: Yes.

Lord BALFOUR OF BURLEIGH: How were they loaded?

Mr. TROTTER: I cannot give details. In the three cases they were coiled up as the railway company states. That is the nature of our objection. The usual way is to put them in canvas coils, but generally a large consignment of cables is put on large wooden drums, the drums being lagged or boarded over, and it is absolutely impossible that damage can occur to them. Some are 10ft. in diameter. There was a cable laid down in Victoria-street in that manner.

Lord BALFOUR OF BURLEIGH: How much loading is there in a truck?

Mr. TROTTER: Any amount up to the maximum weight. The weight of cables is increasing now in consequence of the increased use of lead, copper, and iron cables. If I might put in these advertisements your lordship would see the amount of iron and lead used in many cases, and that decreases the value per ton.

Lord BALFOUR OF BURLEIGH: What is the value?

Mr. TROTTER: £32 to £48 per ton for lead-covered cables, up to £70 or £110 per ton for the ordinary electric cables, which consist of copper and insulating material only. Those are the average values which I have obtained from several makers. The value is decreasing per ton on account of the increased use of lead and iron, and also because there are various substitutes which are now being introduced which are cheaper than india-rubber.

Lord BALFOUR OF BURLEIGH: Is there a tendency to make these articles more valuable and more intricate than they used to be?

Mr. TROTTER: I think not, for this reason, that larger cables are being used now, and the mere fact that cheaper things than india-rubber are being employed for insulation, and lead and iron coverings make the value per ton considerably lower than it was a few years ago.

Mr. COURTENAY BOYLE: Now, surely the term "electric cables" covers articles of both descriptions and bulk; it would cover the main line of an electric lighting company, which might not be thicker than a thumb; and it might cover the concentric copper cable of the London Lighting Company, as thick as a man's leg.

Mr. TROTTER: The copper cable of the London Electric Lighting Company is made in lengths, and it would be rather a conductor than a cable. It is a special article; but I can assure you the values of different sizes of cables up to a half inch section of copper——

Mr. COURTENAY BOYLE: Half-inch section—how would that be carried; would it be carried in coils?

Mr. TROTTER: Yes; coiled upon a wooden drum. It would look like a large, flat, cheese-shaped cask.

Mr. COURTENAY BOYLE: Would not the term "electric cable" cover an ordinary service wire of an electric lighting company?

Mr. TROTTER: Certainly.

Mr. COURTENAY BOYLE: And that would not be coiled over a drum?

Mr. TROTTER: Very generally it is coiled on drums. Otherwise it is sent in canvas-covered bundles. But that is only on a small scale. I saw last night in High-street, Kensington, such drums standing in the street. The conductors are covered. The small-sized cables are worth £75 per ton.

LORD BALFOUR OF BURLEIGH: What have the railway companies to say?

Mr. WILKINSON (Great Western Railway): We have not much to say in answer. The term "cable," as used by us, applies to other than electric cables. Our answer applied to cables generally, not specifically to electric cables. Our present powers are the highest powers in the proposed classification; but we ask you to consider those articles the fourth in the schedule. We think it is reasonable, having regard to value, bulk and risk.

Mr. TROTTER: The definition is "electric cables," and they prefer to include telegraph cables. I am not aware of any other cables. I passed it over when "cables" came up. The word "cable" does not appear in this schedule of class 3, so I waited till "electric cables" came on; but I am not aware that they are used for any other purpose than for the conveyance of current for electric lighting purposes, and for the transmission of power, or telegraphic purposes.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 30, 1890.

Execution by Electricity.—It had been generally supposed that after the numerous legal delays already secured on behalf of the condemned murderer, Kemmler, he would be executed by electricity, in pursuance of the law which has caused so much discussion. Everything had been made ready for the execution, which was to have occurred in the week beginning April 28th. The apparatus for execution had long been ready for use, and had been elaborately tested. The New York daily papers had haunted Auburn Prison for weeks, and had been making the most elaborate preparations to secure a full report of the affair, the law to the contrary notwithstanding. They had begun to publish pictures of the apparatus, the prisoner, and everything intimately or remotely connected with him, and numerous reporters were hanging around, when their hopes of a sensation were blighted by the arrival of a writ of *habeas corpus* reprieving Kemmler, and transferring his case to the United States Courts, where a hearing will be had on June 3rd. The grounds for the transfer were based on the provision of the constitution of the United States, that cruel and unusual punishment cannot be inflicted; and this affords an opportunity for an additional delay, and by so much to delay the time of Kemmler's death. Extraordinary pressure has been brought to bear in every direction to secure his escape, and active efforts will be made for the repeal of the law itself. Kemmler is poor and friendless; the men who are defending him are not particularly noted for philanthropy, nor are they sufficiently young in the profession to incur the immense amount of labour they have for reputation or glory; somebody is paying for all this legal wrangle, and that somebody is popularly supposed to be the Westinghouse Electric Company, although nobody yet has been able to get any definite proof in the matter. The daily papers, however, seem to be unanimous in that opinion. It would be far better for the electrical fraternity at large if the law were repealed, than to have the prisoner escape through a declaration of unconstitutionality.

Storage Battery Traction.—There is great talk just now about the probable growth of storage battery traction in this city. The Julien Company are intending to make important

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extensions of their system immediately, and it looks as if the storage battery car were to become a regular part of our rapid transit system within a short time. The cars in operation so far have run quite successfully, in spite of the fact that they are operated on old horse-car tracks, the rails of which are hardly heavy enough for a storage battery car. It is reported that experiments have been carried on in this city with a view of developing the alkaline storage battery, which was brought into notice some time since in France. Whether anything will come of the experiment remains to be seen; but the line is not an unpromising one, in spite of the low electromotive force of such a battery. The similarity of the alkaline storage battery to the Edison-Lalande battery is very marked in some respects.

The Westinghouse Electric Railroad Company.—The Westinghouse Railroad Company, to which I referred in my last letter, will enter the field with a 500-volt constant potential motor, very similar to those now in use. The motor is to have a Gramme armature, so it is said; and more attention has been paid to improving it in mechanical details than to making any radical departure from the present practice in its electrical features. The new company is backed by a large amount of capital, and has already secured contracts. It is very probable that the result of its operations will be to cheapen street railway electric apparatus in this country. Practically all the work up to the present has been in the hands of the Sprague and Thomson-Houston Companies, and they have recently entered into an amicable agreement not to cut each other's throats, which means that an active opponent will have a fair chance to fight, although he will have to encounter both the powerful companies just mentioned.

Alternating and Continuous Currents in relation to the Human Body.—The physiological experiments recently reported in the English papers attracted considerable attention here. The results seem to American electricians rather sensational, as they are hardly willing to believe that an alternating current is 47, or thereabouts, times more dangerous than a continuous current of the same nominal voltage. That certainly is not in accordance with the results of experiments made here, which, although they show the alternating current to be distinctly more dangerous to life than the continuous, show no such ratio between their destructive effects as was suggested in the Paper referred to.

CORRESPONDENCE.

"ALTERNATING v. CONTINUOUS CURRENTS IN RELATION TO THE HUMAN BODY."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must again trouble you, on behalf of Dr. Harries and myself, for a little space to reply to the correspondence on this subject in your last week's issue.

Mr. Kennelly deals with a physiological effect which we did not enter upon, for the reason that it does not affect the real conditions of the problem. Deeply interesting as the question of the extent to which polarisation forms a part of the apparent resistance of the human body to continuous currents may be, any differentiation between apparent and real resistance does not assist us in arriving at the danger-ratio between the two forms of current. The apparent resistance, composed of real resistance and the counter E.M.F. of polarisation, is what has to be taken into account, because the two together act as the one factor which has to be overcome by the E.M.F. of the generator. When considering the broad question of the quantity of current (at a given E.M.F.) which will pass through the body, we cannot "eliminate the effects of polarisation," for the simple reason that the counter E.M.F. acts to all intents and purposes as a real resistance.

The ingenious method for eliminating the polarisation effect when measuring by Wheatstone bridge, devised by Mr. Kennelly, is worth attention, and we thank him for making it known. We cannot, however, agree that the "disparity between the resistance of the human body to continuous and rapidly alternating currents, as measured by the Wheatstone bridge," may *not* be attributable to some "property peculiar to living organisms." That there is some similarity between the living body and a simple polarisable electrolyte, such as water, we freely admit; but the human body presents a condition entirely *sui generis*. Its physiological actions and reactions are so complicated that the effect of electricity thereon is not to be gauged by comparison with any inanimate electrolyte. Further, the great amount of body *individuality*, both physiological and pathological, renders the problem still more difficult. That "lately killed bodies of animals" and preserved "moist flesh" approximate to the condition of the living body in things electrical, as well as in other things, may well be the case; but even your correspondent admits it may be in a much lower degree.

We venture to think that there is too much tendency to deal with the question either from the purely electrical or the purely physiological side. The two cannot be fairly separated. On the one hand, the body is not an ordinary conductor, nor *is it like any ordinary conductor*; on the other hand, physiological data—so far as they concern the *living* being—can only be considered in relation to *all the parts of that being*. Total resistance and sensation, are, therefore, all we need take into account in our consideration of the matters dealt with in our Paper.

The letter of Mr. Sayers calls for little further comment. The first part is sufficiently answered by my letter in reply to Prof. Forbes, which appeared in your issue of April 11th; while, as regards the latter part, I may point out that we purposely did not draw any conclusion as to "what is the ratio between the muscular fixation E.M.F. and a fatal E.M.F.," because we do not think sufficient is at present known on the subject to warrant any such conclusion.—Yours, &c., H. NEWMAN LAWRENCE.

The Institute of Medical Electricity.

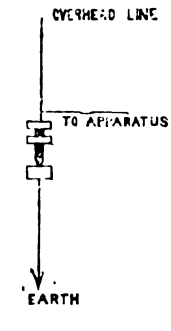
LIGHTNING PROTECTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is one feature in the lightning protector of Dr. O. Lodge, as figured in your issue of May 2nd, which might cause failure in actual practice. That is in the proposal to cause the lightning discharge after entering the apparatus to abruptly turn to right angles on its way to earth, while at the same time providing a somewhat symmetrical passage from "line" to "cable."

We have used upon our lines lightning protectors similar in principle but differently arranged for 18 years, without the instruments protected having suffered in a single instance from lightning.

As our form is based more upon the idea of providing a direct path for the lightning discharge, rather than of turning it aside by obstructions in the shape of impedance coils, I send a sketch of the arrangement.



The line is brought in with as little deviation from a straight line as possible, and faces the earth connection which continues the conductor in the same direction as nearly as possible to earth. The points are $\frac{1}{100}$th of an inch apart, and convey immense discharges without being injured.

In the case of submarine cables the sheath should be continued in the same manner up to the line, while the connection between the line and cable deviates as abruptly as possible from a direct line.

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Discharges of lightning pass readily through the magnet coils of unprotected instruments, and will easily dissipate a pound of copper at a time; therefore it would not be advisable to trust too much to the obstruction of impedance coils.

The oscillations which take place in lightning discharges are not frequently visible in practice. They are, I think, only seen in the induced discharges which take place when a flash of lightning occurs in a direction parallel to an overhead conductor. These are usually of high potential and little heating power. In the other more destructive kind the discharge or discharges which precede the lightning stroke will magnetise needles in one direction, while the overhead conductors are becoming charged under the inductive influence of a thunder cloud and in the reverse direction when the lightning flash takes place.

When the primary lightning flash discharges through a tele graph circuit, which sometimes takes place, there must be no abrupt turns in the conductor, or the lightning may take unexpected courses.

In a case at Whitechapel a few years ago the lightning struck a house and divided between various conductors, one of which was the lead in of an overhead telegraph line. The copper conductor of this lead was blown out completely from the junction of the line to the instrument, except where it had passed in almost a rectangular manner over the parapet; there the lightning had made a short cut and thrown the coping into the street, killing a boy who was underneath, but leaving that part of the conductor intact.—Yours, &c., F. HIGGINS.

17 and 18, Cornhill, E.C., May 8, 1890.

ELECTRIC TRAMWAY SYSTEMS.

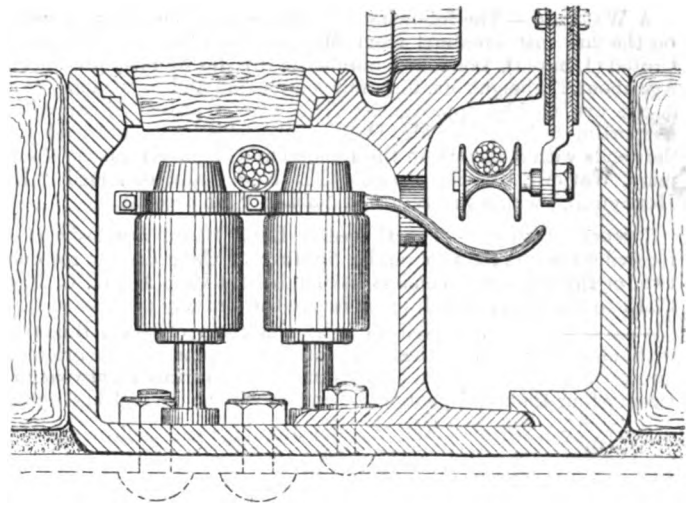
TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of last week you publish a description of an electric tramway system called the Waller-Manville, for which several features are claimed as new. I beg to point out to you that this system is by no means new, having been patented by me in 1887. In my specification (Improvements in Electrical Tramways and Railways, No. 14,029, October, 1887), a copy of which I enclose) will be found a full description of this method of insulating and collecting from a flexible cable. To Mr. Volk, of the Brighton Electric Railway, is due the credit of having first employed insulators of the telegraphic form for an electric tramway system (see specification No. 9,388, August, 1885), and also of providing removable lids, allowing access at all times to them. Mr. Volk, however, *fixed* his conductor to the insulators; and it was to get over the difficulty caused by the breaking of the insulators that I designed the system with a flexible cable *resting* on hooks supported by insulators, as shown in my specification and your description of the Waller-Manville system. This method of insulating and collecting from the conductor is the very essence of my system; and it will be seen on comparing my specification with your description that the method employed in the Waller-Manville is identical. The claims made of the conductor being removable through the slot, accessibility of the insulators, collecting arm rigidly fixed to the car, &c., are all mentioned in my specifiation; and it is difficult to see any new points in the Waller-Manville system except a slight alteration in the form of the conduit and one or two mere matters of detail of which any mechanic could sit down and work out innumerable shapes.—Yours, &c., F. C. ALLSOP.

165, Queen Victoria-street, E.C., May 12, 1890.

[In order that our readers may judge for themselves as to the identity of the two systems, we append a brief abstract from Mr. Allsop's specification, together with figure.—ED. *E.*]

"This invention relates to improvements in the apparatus for containing, insulating, conducting, and collecting the current on electrical tramways and railways, by means of which I greatly simplify the appliances, and, by such forms of conductor and methods of insulating, reduce the mechanical strain on the insulators to a minimum. In carrying out my invention I employ a channel or trough (open at the top, which top is flush with the roadway), of rolled iron or other suitable material, and of rectangular or other suitable section, and constructed preferably in lengths of about 10ft. In this channel I then place the ordinary girder type tramrail in such a position that it divides the channel into two separate parts, so that each part forms a separate channel by itself, the one preferably larger than the other. The larger one I call the 'insulator channel,' and the smaller one the 'collecting channel.' From the rail being so placed, the smaller one, or 'collecting channel,' has on the top, which is exposed to the roadway, a ¾in. slot running the entire length of it, and the larger one, or 'insulator channel,' a much wider opening, into which I afterwards fit a lid that is at all times removable, and which prevents all dirt and wet from coming into it from the roadway. In this insulator channel I place the insulators, preferably in couples with about 3ft. between each couple. To each couple of insulators is affixed, in such a manner that it is perfectly insulated from the channel, a rod of copper, brass, or other suitable alloy, the further end of which is curved preferably in the form of a hook, and passes (without touching the sides) through a hole drilled in the girder rail which forms the partition, and projects a little way into the smaller or collecting channel. On these hooks which project into the collecting channel I lay my conductor, which consists of a cable of copper or other suitable wires; this cable merely resting on the hooks and not fixed to them in any way. Fixed to the axle or axles of the car I provide a collecting arm, insulated in the usual manner, which passes through and runs in the slot in the top of the collecting channel. To the bottom part of this arm is fixed a grooved roller or rollers at such a height that it is always above and clear of the hooks that support the cable. I then place the cable over the roller so that the arm moves along with the car the cable runs over the roller, being lifted off each support as the arm passes it and falling back into its place again as the arm moves on. These rollers collect the current from the cable, and from the rollers it is transmitted up into the car by the arm, and from there by a lead to the motor in the ordinary manner. The return is effected by 'earth,' or by another cable fixed on uninsulated supports in the collecting channel and worked by a separate roller in a similar manner to the insulated cable. In cases where there are likely to be many cars at work upon the same line I provide a second "feed" conductor (*see* figure) of any



suitable form; and this conductor I place in the insulator channel and fix it in such a manner to the insulators that it is in electrical contact with the hooks that support the collecting cable. It thus feeds this cable at every hook, and by this means a larger current could be transmitted than otherwise."

DYNAMO AND MOTOR REGULATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue for May 9th I notice a reference to Messrs. Crocker and Wheeler's "Arc Current Motors." By a reference to the specification, No. 3,556, 1889, a copy of which I send you by this post, you will see that I have applied this principle to both dynamos and motors.—Yours, &c. O. FIRTH.

Bradford, May 12, 1890.

[In the patent specification referred to Mr. Firth proposes to regulate "the current developed by a dynamo-electric machine and the power of electric motors," both by moving the field-magnets away from the armature on either side of it, and by sliding the field-magnets along parallel to it.—ED. *E.*]

THE WELLINGBOROUGH AND DISTRICT TRAMROADS BILL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last week's edition you say this Bill was passed with the clauses proposed by the opponents, the South of England Telephone Company. This statement is erroneous, as the real facts are as follows:—

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At the conclusion of the evidence and speeches of counsel, the Chairman stated that the Committee would insert the clause as proposed *by the promoters, the Tramway Company*, with this addition: That, if required by the Telephone Company, words should be added to carry out the offer made by Mr. Moulton of bearing the expense of protecting *existing telephone lines.*

The promoters' clause runs thus: "As regards electric circuits erected or laid down by the Telephone Company, after the construction of the works of the Company, this sub-section shall only apply if reasonable and proper precautions have been taken in the erection or laying down of such last-mentioned circuits to *insulate and protect them from external electrical influences.*"—Yours, &c.,

STEPHEN SELLON,
Engineer to the Promoter.

May 14, 1890.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

A WARNING.—The following description is given of a man who, on the 2nd inst. obtained from Messrs. Woodhouse and Rawson United (Limited), London, a number of articles by false pretences. Age about 27, height 5ft. 9in., fair complexion and moustache, cast in one eye, shabby appearance. This person presented an order purporting to be from a Mr. Honeywell, of Surbiton, and paid for the goods with a cheque on the London and County Banking Company, Watford Branch, signed "F. Hood," and endorsed "H. Honeywell," which was returned marked "No account."

TENDERS INVITED.—The Clevedon Local Board are desirous of receiving tenders for the public lighting of their district for one, two, or three years. Tenders have to be sent in to Mr. H. C. Fry, Clerk to the Local Board, on or before the 3rd day of June next.

——— It is intended to light the town of Sofia, Bulgaria, with electricity, using the water of the Boyena as the origin of force. The cost of initial establishment is estimated at twenty to twenty-four thousand pounds. Tenders will be invited in August.

SALES BY AUCTION.—Mr. Wooller Jennings will sell by auction, on Tuesday, June 3rd, at the Schmidt Douglas Electric Works, Albion-court, Bradford, and on Wednesday, June 4th, at the Repository, Canal-road, Bradford, at eleven o'clock each day, a large quantity of electric plant, machinery, and utensils. Mr. Edgar Musgrave, chartered accountant, of 1, Bank-street, Bradford, is the official liquidator; and Mr. Thomas England, Town Hall Chambers, Halifax, is solicitor to the liquidator. Further particulars are given on page xv. of advertisements, and all particulars can be obtained of the auctioneer, 43, Old Market, Bradford.

——— HORNE, SON, AND EVERSFIELD will sell by auction, at the Royal Arsenal, Woolwich, on Thursday next, at eleven o'clock, surplus and unserviceable Government stores, including theodolites, old brass, old copper, old steel, aluminium turnings, old gun metal, old zinc, old tools, old jute, and wheels. Further particulars can be had of the auctioneers, 17, Great George-street, S.W.

——— MR. F. J. BISLEY sells on Wednesday next, at Albion Works, Haymerle-road, Old Kent-road, S.E., a quantity of plant and machinery, tools, &c. Particulars of the auctioneer, 63, King William-street, E.C.

MESSRS. STAFFORD AND EAVES.—Referring to our note respecting the dissolution of partnership of Messrs. Stafford and Eaves, we are requested to state that the dissolution does not in any way interfere with the progress of the business, which is being largely extended, and is still carried on under the same style and management as before, at the Volt Works, Coventry.

DISSOLUTION OF PARTNERSHIP.—The partnership between H. Moss and T. M. Broughton, trading under the title of Moss, Broughton, and Co., at Lawson-street, Great Dover-street, London, S.E., as mechanical and electrical engineers, has been dissolved.

THE MILITARY EXHIBITION, CHELSEA.—In our note of last week we should have mentioned that the electric lighting of this Exhibition is on the Thomson-Houston system, and is installed by Messrs. Laing, Wharton, and Down.

MESSRS. RANSOMES, SIMS, AND JEFFRIES.—This firm have been awarded the first prize for Portable Steam Engines exhibited at this year's show of the Adelaide Royal Agricultural Society. The report mentions, in addition, that the engine to which the award was made was much admired for its construction and smoothness of working.

MESSRS. ERNEST SCOTT AND CO.—This firm have secured the contract for lighting the new offices and printing works of the *Bolton Evening News*. The installation will consist of 2,150 light "Tyne" compound-wound dynamos fitted with heavy fly-wheels, to be driven from two 20 horse-power "Otto" gas-engines, which also drive the printing machines, &c. The installation will ultimately consist of 400 16 candle-power incandescent lamps, and main and branch cables are provided for this number. Of this number only 280 lamps will be installed at the present time. Messrs. Bradshaw and Lass, of Bolton, are the architects, and they are supervising the installation.

NOTTING HILL COMPANY.—This Company have issued contracts to lay their mains forthwith in the following London streets:—High-street, Notting Hill; Pembridge-gardens, Linden-gardens, Clanricarde-gardens, Chepstow-place, Pembridge-square, Pembridge-place, Dawson-place, Pembridge-villas, Pembridge-crescent, Chepstow-villas, Kensington Park-gardens, Kensington Park-road, Ladbroke-square, Ladbroke-terrace, Victoria-gardens, Ladbroke-road, Notting Hill-square, Holland Park. Residents in or near these streets desiring to be supplied with light before the winter of 1890 should apply at once at the engineer's office, 105, High-street, Notting Hill, London, W.; or at the City offices, 9, Austinfriars, E.C.

MESSRS. COOPER AND CO.—We have recently devoted some space to the subject of artistic electric light fittings, and have this week had the pleasure of witnessing what can be done in illustrating the artistic application of the electric light. On Wednesday last a private view of an exhibition of this character was given on the premises of Messrs. Cooper and Co., of Great Pulteney-street, Regent-street, W., in which between 60 and 70 incandescent lamps of various candle-powers were distributed over a number of rooms very effectively furnished. Such installations should be much more frequently shown, as these displays cannot but produce an extended demand for the electric light. The numerous visitors expressed their pleasure at the display, and great credit is due to Messrs. Cooper for the effective manner in which the whole exhibition was carried out. The current was supplied from the Grosvenor Gallery.

THE QUEEN'S VISIT TO WADDESDON.—To emphasise our remarks in the above Note, it may be mentioned that the correspondents of the daily press present at the ceremonial at Waddesdon on Wednesday last are unanimous in recording the great attraction which the artistic setting of the electric lamps proved to the invited guests. This was more particularly the case with reference to what is termed "the new process" of fitting the chandeliers, pedestal lights, &c. with what appear to be wax candles, with the electric light springing therefrom. It may be mentioned that the recent fire at Waddesdon Manor was discovered by means of the electric current before much damage was done, thus preventing what would undoubtedly have proved a sad disaster.

BOOKS, &c., RECEIVED.

"*Journal* of the Institution of Electrical Engineers." Vol. XIX., No. 86. (London: E. and F. N. Spon.)

"Notes on Electric Lighting." By Rev. Gerald Molloy, D.D., D.Sc. (Dublin: Eason and Son.)

The "Wimshurst Electrical Influence Machine." By William Phillips Mendham.

COMPANIES' MEETINGS.

The Western and Brazilian Telegraph Company (Limited).

The nineteenth ordinary general meeting of this Company was held on the 9th inst. at Winchester House, Old Broad-street, under the presidency of Mr. W. S. Andrews.

The SECRETARY (Mr. R. M. Cunningham) read the notice calling the meeting and the minutes of the eighteenth ordinary general meeting.

The Report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—We are not meeting to-day, fortunately, under quite such adverse circumstances as we did on the last occasion

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when we came together. At that time, you will remember, we were expecting, owing to interruptions, reductions of rates, and other causes, an exceedingly bad half year's traffic, and we were threatened with a competition both north and south of our system. Opposition cables appeared to be not merely on the cards, but almost, as far as one could see, on the point of being laid. I am glad to say that the apparent darkness of those circumstances has been a great deal mitigated. To begin with, the receipts for the half-year very largely increased towards the end of the period. You will remember that when we met we were under an Empire; and we woke, either next morning or the morning after, I forget which, under a Republic. Well, now, in times of political disturbance there is always a very great increase in the interchange of telegraphic communications; and the general effect was, that during the last two months of the year the receipts were very high indeed, whereas in the four previous months they were very low. The outcome of the whole half-year of course compares unfavourably with that of the corresponding half of 1888, in which, if you remember, we took the extraordinary total of £110,000. That was the highest amount of receipts we ever realised. These large returns arose partly from the high tariff and the high rate of exchange, and partly from the enormous commercial activity and speculation that prevailed during that half-year, which recorded the highest tide-mark in respect of telegraphic revenue. The Company, nevertheless, has managed to scrape together for the last six months £86,403—no doubt, a pretty large decrease compared with £110,000; but nothing like so large a diminution as we were anticipating when we last met. I will now deal with the expenses. You will find that taking the expenditure under abstract "A." the expenses at stations, the total works out practically at the same figure as it did in the corresponding period of the previous year, the difference on the gross amounting to only £11. 6s. 7d. I take it that you will not want any explanation of this from me. In the same way, taking abstract "C," that is, the expenses in London, the totals are again so closely identical that they do not call for any explanation. The difference there is one of £61. 13s. 2d., as the effect of more work having had to be done. There was not a very great deal, but still more had to be done; and under the circumstances, therefore, these figures give us a satisfactory outcome from the point of view of commercial expenses for the half-year. The only real increase—and it is one which finds no favour with the Directors, although we find it extremely difficult to control—is under the head of "Ships." You will remember that we had to bring our own ship the "Norseman" home in order to be repaired, and that we replaced her by another called the "Buccaneer," which we took upon charter. Well, the expenses of the half-year would not have been so great but for the fact that the "Norseman" was detained by the strikes at Leith. She would have got away a great deal sooner but for those strikes, and consequently the chartered vessel would have been relieved sooner too. The result is that there is a net increase under the head of "Ships" of £6,281 9s. 7d. Of course, had we not had that vessel, the loss that we should have sustained on revenue account would have been very large indeed, because of the interruptions. As the Report tells you, there is an item for more cable used, £928, and there is an extra amount written off the ships for depreciation of nearly £900; so that it is quite correct for me to say that the increase in our expenses is owing practically to the ships and the maintenance of the cables. With respect to the repairs done to the "Norseman," they were very extensive, and of course she was sent back almost, if not quite, as good a ship as ever she was. We thought, therefore, that as we had improved her value, we should charge the amount to her account. Of course, the wages, coals, and other things had to be charged against revenue, but the actual outlay on the ship was charged to the ship. This appeared to us to be reasonable; and I hope that you, gentlemen, will think that it is right. After all these figures are boiled down we come to this, that including the amount brought forward, £4,072 9s. 8d., the dividend received from the Platino Company £7,379, the balance to the credit of revenue is £57,462. 18s. 6d. From this has to be deducted £13,500 for debenture interest, £7,500 for renewal fund, and £5,600 for debenture redemption fund. This leaves an available balance of £30,862. 18s. 6d., which allows of a dividend at the rate of 4 per cent. per annum, free of income-tax, for the half-year, and leaves £3,248. 16s. 6d. to be carried forward. I must confess that when I had the pleasure of meeting you last, I did not think that the outcome for the half-year ended December 31st would be as satisfactory as it has been. I was saying just now, that the Company went to sleep under an Empire, and woke up under a Republic. You will remember that at the meeting we held, we were discussing the steps that we ought to take with the Brazilian Government. Of course our movements were rather precipitated by what took place in Brazil. We thought that after a crisis of that kind friendly intervention might be brought to bear upon the newly-installed Government, which would prove, perhaps, to be very useful to us: and we therefore sent our papers to the English Government, with the request that they would aid us in Brazil if, of course, they were satisfied with the nature of the case we presented to them. I have not had much to do with the British Government, but I have always found that it is an exceedingly difficult one to convince. If you can convince the British Government, you may be pretty sure that your case is not very bad. Information was called for, documents were required, returns had to be made, and every information that was needed was put before our Government and fully considered by them. And I am glad to say that the result of their investigation of our case was that they arrived at the conclusion that we had a very good case, and that a remedy certainly ought to be found for our grievances. In the end the British Minister at Rio was instructed to give his friendly support with the Brazilian Government to the petition that we had sent in, and to the claims that we had made under our concession and otherwise. Of course, in a matter of this sort one Government acting with another Government can only give friendly assistance. The Brazilian Government is paramount in its own country. It can be forced to do nothing, and the only method to pursue is to act by way of persuasion, by getting up your case as clearly as you can. The whole thing is now under consideration. We have given every kind of information that we could; we have put forward every fact fairly and squarely, because we believe that our case is a good one; and the more the facts, information, and documents are put forward, as you remember we laid them before you at the last meeting, the better is our chance of success. Of course, with a new Government like that of the United States of Brazil, it is quite impossible to tell what is going to occur. We cannot say what resolution the Government may come to upon these facts and representations. We can only hope that it may be favourable; and we must continue to stand ready to do our best at all times, and, under the most favourable conditions, to continue to force the matter on their attention. Gentlemen, at the last meeting, as I said just now, we were threatened, as you will remember, with two competitive lines. One was the line from the Argentine territory to Europe; and although one does not, perhaps, feel very great surprise at the extraordinary statements promoters put forward for reaching the pockets of the public, we were surprised in that case, because the Argentine Federation had a duplicate cable communication already. They had a cable by the east coast and a cable by the west coast. These were competitive cables; and therefore there was every apparent certainty that at no time would they be interrupted, and they would have certainly every possible facility and good means of communication. Still, it was proposed to spend upwards of two millions, with a guarantee of 5 per cent. interest, at a time when the premium on gold in Buenos Ayres was something like 205 per cent. Of course, the effects of the political storm in Brazil did not stop at the coast of Brazil. The surges seemed to influence the state of things in the whole Argentine Federation; and the premium on gold, instead of going down, continued to go up. I think I remember seeing it in the last six weeks at something nearer 300 than 200. Two millions and upwards were proposed to be raised, with a guarantee of 5 per cent., which would have to be paid in gold. This, in a country where gold was at a premium of something like 275 or 280 per cent., appears to have been regarded as a thing which could not be carried out without extreme difficulty. But, as far as we can see, owing to the embarrassment of the Argentine Government, there is, at all events, no present prospect of this scheme going before the public again. That was not the only matter before investors. There was another concern between Brazil and the United States of America, which was of a somewhat similar nature in its incidence. But according to the terms of our concession that cable could only compete for a very limited portion of the traffic if it were made; and our contention is, that it could not pay with that small traffic, and there is no guarantee in this case. Consequently the scheme appears to have fallen back a bit, and I am pleased to say does not look so formidable now, and we may hope that these two schemes will eventually fall through. But people seem to be always quite prepared to come forward and subscribe money to be lost in cable operations, as though they rather relished being phlebotomised. I do not know that there is anything more for me to say except that there is to be a Telegraph Conference this year, at which all the companies will be represented. I do not know that there is anything to be feared with regard to the rates. My impression is that there will not be much done there to affect the interest of extra European telegraph lines. I might just make an observation as to the current state of things. Of course, it does not properly belong to the half-year under review; but no doubt you would like to know—you are entitled to know—that our receipts this half-year are on the whole satisfactory. You know that at the last two meetings it was our unpleasant duty to deplore the interruptions to the cables, and we told you that these things would be in one year particularly bad, and in another particularly good. Well, I am pleased to say that, as far as the year has gone, it promises to be a good one. Our receipts are averaging better than they did at the corresponding period of 1888 by some £6,800. That also is with a lower rate of exchange; and, as compared with 1889, there is also, I am glad to say, an increase of £425; so that altogether up to the present time your working promises to be satisfactory. I do not like to say anything more than that, because sometimes when we do indulge in sanguine expectations we are brought to book in round terms afterwards for it. I remember a Director of one of the Companies once saying that not one of his cables was interrupted, and when he got back to the office he was told that three of them in the meanwhile had broken down. With these remarks I beg to move:—

"That the Report and accounts for the half-year ended December 31, 1889, now submitted, be and the same are hereby approved and adopted; and that a dividend of 6s. per share, free of income-tax, making £4 per cent. for the year, be declared and paid on the 15th inst."

Mr. H. WEAVER seconded the motion.

Mr. CLARK said that the chief item of interest in the accounts was the enormous loss caused by the repair of the Company's ship. He believed that the present repairs were chiefly owing to the renewing of the boilers. If that was so, it seemed to him to be an immense amount. The total sum they had paid for their ships' repairs had been £17,000 odd, which he thought was very large.

Mr. PETO said it was always very pleasing to hear the lucid statements from the Chair, from which it might be clearly gathered that they had a very fine property, and that they had every reason to be satisfied with the way in which it had been managed. As far as he was concerned, he confessed that he would be very much pleased to have much less interest if the debentures could be converted into Debenture Stock. He was told, however, by the solicitor to the Company that there was a legal difficulty in the way. But if it could be effected he would be very glad indeed to welcome the change, as he thought it would be a very fine thing for the Company.

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The CHAIRMAN, in reply, said: We have depreciated the ships regularly every year. We have usually depreciated them at the rate of six per cent. In the present case, having charged these considerable renewals to the value of the "Norseman," we thought that we might extend the figure a little, and consequently we have depreciated her ten per cent. It is about five years ago since she was repaired, and I may say, in reference to the question which the hon. proprietor put—and it is a very natural one—"has all this money been spent upon the boilers?" it has not. It was not merely the ship's boilers that wanted repairing, but her decks and masts, and in fact she had a thorough overhaul, and has been made to look like a new vessel. She has undergone a most careful survey, and has been put right in every respect. I do not want to trouble you with too many details on occasions like these, but you are aware that we were duplicating a part of the cable, a work at which she was present. There were some 284 miles of cable put into the sea. Of course we cannot give you all the details that we should like; but we are always happy to answer if we can the questions of hon. proprietors. As you are aware, we have had the subject of the debentures constantly before us. We have endeavoured to get the best advice we could about it, and we have been told that we must not move in the matter just now over and beyond the strictly legal question.

Mr. CLARKE asked how long the "Norseman" might be expected to last without further large repairs?

The CHAIRMAN: I think she ought to be good for another seven or eight years.

The resolution was carried unanimously.

The CHAIRMAN next moved:—

"*That Mr. C. W. Earle, who now retires, be and is hereby re-elected a Director of the Company.*"

Lord R. H. BROWNE seconded the motion, which was carrried unanimously.

The CHAIRMAN moved and Major WOOD seconded:—

"*That Mr. H. Weaver, who now retires, be and is hereby re-elected a Director of the Company.*"

The motion was carried unanimously.

Mr. PETO proposed the next resolution as follows:—

"*That Mr. John Weise and Mr. J. G. Griffiths be and are hereby re-elected Auditors of the Company, and that their joint remuneration be 100 guineas.*"

Mr. MACHELL seconded the motion, which was carried *nem. con.*

The CHAIRMAN: I am asked to mention something here that affects us very little now, although it may affect us in certain directions in the future, and that is that we have been discussing the question of doing something in the way of reducing our press rates. We may be shortly in a position, I think, to announce a reduction of them. That concludes the business, and I thank you for your kind attention.

Mr. PETO proposed a vote of thanks to the Chairman, Directors, and the staff for their efficient conduct of the Company's business for the past year; remarking, as he had said before, that he thought they had a very fine property, and they ought to be thoroughly satisfied with the management of it.

Mr. CLARKE seconded the resolution, which was carried unanimously; and,

The CHAIRMAN having briefly returned thanks, the proceedings terminated.

The West Coast of America Telegraph Company (Limited).

The thirteenth ordinary general meeting of this Company was held on Wednesday at Winchester House, Old Broad-street, under the presidency of Mr. Alfred Marshall.

The SECRETARY (Mr. Frederick Robinson) read the notice convening the meeting, and the Report of the Directors was taken as read.

The CHAIRMAN: We have, as usual, placed the figures of the previous year against those of the year just passed, so that you have been able to compare them at your leisure. I will, however, allude to some of the principal items. If you refer to the revenue account you will see that the gross earnings of the Company during 1889 have been £83,568. This very handsome amount has been produced by the very good traffic we have had during the past year. We attribute this to the good business which has been done on the West Coast; then to the formation of a large number of joint-stock companies, and the large speculation in nitrate, which has given us a great deal of work; and to the circumstance that the competing line on the East Coast, which competes for the traffic from Valparaiso, has for some time been interrupted, so that we have had a certain amount of traffic which would otherwise have gone over their line. I can only congratulate you on these handsome returns for the year 1889. A little further down in the same account you see interest account. At first sight it seems an anomaly that though we have had a larger amount invested in the reserve fund the interest account should show a smaller amount. The reason is that this item not only shows the dividends we have earned, but from it are deducted any discount that we may have to pay in discounting the remittances that come home from the other side. In 1889 we have had to discount a much larger amount of bills, and consequently that expense has been greater. At the same time the amount for 1888 included a profit we made in that year on the sale of stock and reinvestment—a profit which was not earned in the past year—and some dividends which were received, exceptionally, before the end of that year, and which for the year 1889 were only received in January last, and which will appear in next year's accounts. I have referred to this because I have had questions asked me on this subject, and I anticipated that some of you would require the explanation which I have given, and which will therefore save you the trouble of asking for it. On the left-hand side of the account, the only amount requiring any reference is the West Coast expenses account. These expenses have been about £3,000 higher than they were in the previous year, the reasons being that we have done more work, and we have had more clerks. The clerks, too, in time, get an increase of salaries; and more wages have been paid. We have had more rents and taxes to pay on account of the increased number of offices; and the passage-money has been heavier, because some time-expired clerks have returned from the coast, and been re-engaged, their fares having been paid. On the whole, however, the increase in the expenses is small compared with the handsome increase in the earnings. I now come to the point mentioned in a paragraph in our Report, in which we have given you the reason for adding the very large sum of £25,000 to our reserve fund, and I will at the same time take the opportunity of answering questions which have been put to us, and anticipating questions which some of you gentlemen may also wish to ask us. I refer to the threat of competition mentioned in our Report; and in order to explain this matter as nearly as I can, I will give you a small history of the way in which our Company is worked. The concession under which the cables are worked is not a monopoly; it is merely a permission of the Chilian Government, which has exercised its right of giving permission to others to lay a cable parallel to ours. As far back as the year 1887, in February, permission to lay a cable was given to Don Enrique Gandarillas, a gentleman with whom we are not acquainted. No doubt this was in the interest of the Central and South American Telegraph Company, our neighbours, who were then and are still working with us under a joint agreement. This concession came to an end in February, 1889, but the Chilian Government renewed the permission to lay the cable for a year up to 1890; and in February last they again renewed their permission, and granted an extension of the concession up to February, 1891. Meanwhile, during the present year a steamer has been sent out by the Central Company to act as a repairing steamer, and consequently the agreement which we had with them, and the retaining fee which they paid us, will not be paid to us after the arrival of that steamer on the coast. Then last month there appeared in the New York *Chronicle* a notice that the Central Company had asked its shareholders for an increase of capital to the extent of $1,000,000 United States currency for the purpose of laying cables parallel to ours. About the same time notice was sent to us from the Central Company that the joint working agreement, which is dated July, 1882, and which was terminable at six months' notice, would come to an end on October 1st next. This appeared only a few days before our Report was issued to you. Now, we believe it is not possible that by October 1st next a cable can be laid—the time is too short; but we believe it to be quite possible that a cable can be manufactured, sent out, and laid before the expiration of the concession given to Mr. Gandarillas, and terminating at the end of February. We thought it very important that the shareholders should be informed of this threat at the earliest opportunity, and therefore we embodied it in our Report, which was about to be issued with the accounts for the past year. We hope before the Directors of the Central and South American Company definitely take so serious a step, that they will suggest some new working arrangement with us. They know perfectly well that we are prepared to treat with them. If there are any questions that any gentleman would like to ask me I shall be happy to answer them to the best of my ability before putting to you the formal resolution adopting the Report and accounts.

Mr. LAMONT inquired if the Central Company was an American Company.

The CHAIRMAN: Yes, there are two companies working between Galveston and Callao. In further reply to Mr. Lamont, the CHAIRMAN said: All the European messages that we get go over the Central Company's lines also. There are two lines to Valparaiso—the Galveston route (call that our route) and the Eastern route *viâ* Lisbon, the latter traffic going over the Brazilian Submarine and the Western and Brazilian lines; but we have got our cables into such good working order that very few of the merchants in Valparaiso avail themselves of our competitors. I think we must get 80 or 90 per cent. of the traffic.

Mr. LAMONT: Are the Directors taking steps to see if any agreement can be come to, because if we enter on competition it will be suicidal?

The CHAIRMAN: The President of the Central Company has been informed that we are open to be treated with, and we are in hopes that they will do so before they take any definite steps. There may be a personal meeting of some kind between us.

A SHAREHOLDER: Have the Central Company yet obtained the increase of capital you mentioned?

The CHAIRMAN: We have not heard that they have got it, but there are powerful persons connected with the Central Company, and we have no doubt that if they are in earnest they can procure the funds they may require.

Mr. J. TAYLOR asked which way the River Plate messages of the Company would go if they broke with the Central Company?

The CHAIRMAN: The Central Company would not let the traffic go over the Western and Brazilian lines if they could help it. As long as they have not a cable of their own, we should continue to give our messages to them.

Mr. J. TAYLOR: But if they had the cable?

The CHAIRMAN: We should not get the European messages *viâ* Galveston. If we could get messages in Peru we should send them over our line and *viâ* Lisbon. Probably customers in Peru would prefer the short route *viâ* Galveston.

Mr. TAYLOR: There is hardly any question of short routes in connection with telegraph cables.

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A SHAREHOLDER inquired how the Company's position would be affected, roughly, supposing the new route were made, and that there was, as he imagined there would be, distinct hostility on the part of the Central Company towards the West Coast Company. Would the latter be shut off from their present business or a great part of it?

The CHAIRMAN: If these cables were laid we should have to try and get some European traffic by the Lisbon route. We should, for instance, have to try and get Lima telegrams over our own line *viâ* Buenos Ayres, Rio, and Lisbon. They would also, of course, compete for the local traffic, and that would entail a reduction of rates.

Mr. J. TAYLOR: When the Central American Company get their cables, I should think the Brazilian Company would be very glad to make the same arrangement with you as you had with the Central Company.

The CHAIRMAN: I have no doubt they would, but it is too early to go into that matter.

Mr. TAYLOR: But not too early to look around you.

The CHAIRMAN: We are quite alive to doing what we can to protect the interests of the shareholders.

General HAMLEY presumed that the Directors regarded as authoritative the paragraph in the American paper on which all the alarm had been founded.

The CHAIRMAN: All things combine to make it certain that it is founded on truth. They have given us the notice I referred to; they have been asked if the concession is theirs, and they did not deny it; and they have got their own steamer.

General HAMLEY: Would it be improper to ask whether, in whatever communication has occurred since the alarm was first raised, the tone of the other Company has been conciliatory or hostile?

The CHAIRMAN: It has been declining to answer.

Mr. TAYLOR said he had been under the impression that the Company possessed a monopoly.

The CHAIRMAN said that the concession they had was not coupled with a monopoly. He added: The agreement with the Central Company must have worked with satisfaction up to now to that Company. The New York paper says the agreement was not satisfactory, but we regard that as an excuse. It has evidently been satisfactory for the last seven years. If not, they could have given us years ago six months' notice to terminate it.

Mr. TAYLOR thought that the shareholders had rather been living in a fool's paradise for the last two years. The fact that the traffic had been so satisfactory was an additional reason why the Central Company should step into the shoes of the West Coast Company.

Mr. LAMONT considered the Directors' fees, £1,475, were too large to be divided among three gentlemen. He apprehended that the work attaching to the directorate in the last two or three years must have been very small. He did not think that any amount of work could be shown to represent £500 a year. He presumed that the Directors did not meet more than once a week, and in present circumstances he thought that amount was excessive.

The CHAIRMAN: Though the Directors do not meet oftener than you state, still, speaking for myself, I am sometimes four or five times a week attending to the business of the Company; and, if necessary, I should do so every day. My colleagues, too, are always available. If we do not meet at the Board we come to the office and discuss matters; and we are always at hand for the negotiation of any important business.

General HAMLEY supposed that if the Directors received any message that the Central Company were disposed to negotiate with them the shareholders would be informed of the fact.

The CHAIRMAN replied that steps would be taken to give them the earliest information.

A SHAREHOLDER asked whether it would be well to strengthen the Board at such a juncture by the addition of a gentleman conversant with the whole matter, who could give his attention to it, and, perhaps, go to the other side, and see what was best to be done.

The CHAIRMAN: If it came to any negotiations, I am ready to start at any moment on behalf of the Company; and, as regards the strengthening the Board, I have been in negotiation with a gentleman who is a very competent man, but whose other duties have not as yet enabled him to join us. He then proposed the adoption of the Report and accounts.

Mr. HENRY ROBERTS seconded the motion, which was carried unanimously.

The CHAIRMAN then proposed the payment on the 21st inst. of the bonus recommended of 2s. a share, tax free, making the return 6 per cent. for the year. He said: We have added a large amount (£25,000) to the reserve fund, and I hope this will strengthen us very much in any negotiations which may take place, and which I hope will take place; and the dividend of 6 per cent. per annum is on the whole not bad for an investment. I think this proposal will be satisfactory to you generally.

Mr. FREDERICK WALTERS seconded the resolution, which was carried unanimously.

The CHAIRMAN then proposed the re-election of the retiring Directors, Messrs. Roberts and Walters.

Mr. C. E. MASON (a shareholder) seconded the motion, observing that Mr. Roberts had been a member of the Board for many years, and joined the Company when it was in a very different position; and Mr. Walters had also been a Director for some years. The difficulty that had now arisen would give the Directors some anxious thought, and he believed the shareholders might rely on everything that was possible being done to protect the interests of the shareholders.

The resolution was unanimously adopted.

On the motion of Mr. TAYLOR, seconded by Mr. LAMONT, Mr. John Weise was re-elected the auditor.

Mr. TAYLOR afterwards referred to the large amount paid for the insurance of the repairing steamer. He believed that on this account an amount had been paid which, if it had been allowed to accumulate, would represent some £20,000. He thought the Company was strong enough now to establish an insurance fund of its own. No vessel had less risk than a repairing steamer.

The CHAIRMAN said that the suggestion should be considered by the Directors.

A SHAREHOLDER proposed a vote of thanks to the Chairman and Directors, observing that they must have had an anxious time, and that the shareholders ought to feel grateful to them.

Mr. TAYLOR seconded the motion, which was carried unanimously.

The CHAIRMAN: I thank you for your kind expressions. I can assure you that it has been and is a very anxious time for us, and we are doing everything in our power to save your property. I hope we shall be able to give you better news at an early opportunity.

The proceedings then terminated.

Maxim-Weston Electric Company (Limited).

The ordinary general meeting of this Company was held at the Cannon-street Hotel on Friday, May 9th, to receive the Directors' Report and Accounts, to elect Directors and auditors, and to transact the ordinary business of the Company. Mr. J. Blades Gooding presided.

Mr. R. M. BARLEY (Secretary) read the notice calling the meeting, and the Report was taken as read.

The CHAIRMAN: Gentlemen,—I think that the best thing that we can do is to adopt the Report as it stands. Necessarily I think it will give rise to some discussion (hear, hear); and therefore I beg to move that the Directors' Report as submitted and the accounts be adopted.

Mr. SWABY: I shall have much pleasure in seconding it.

Mr. THORNE thought they were entitled to some explanation from the Chairman before the resolution was put to the vote (hear, hear). If they carried the motion their mouths would be sealed, and they could do nothing afterwards. He would have to move an amendment that the Report be not adopted.

Mr. WOODHEAD: What is the sum of "£458 Directors' fees" for? Is it for losing the shareholders' money? I second the amendment.

Mr. CANE said that it seemed things were to be rushed through in a very extraordinary manner; and in order that such should not occur he would move another amendment. He was of opinion that the shortest and wisest way to deal with the whole concern was to appoint a Committee of Investigation thoroughly independent of the present Board; and he would therefore move an amendment:—

"*That a Committee of Investigation be appointed to inquire into the affairs of the Company, and to report to an adjourned meeting in four weeks' time.*"

Mr. RITCHIE seconded.

Mr. THORNE urged that his amendment should be put that the Report be not adopted till they had received a statement from the Chairman.

The CHAIRMAN: Well, gentlemen, in response to the invitation of Admiral Sir E. Inglefield, I rise to explain the disastrous balance-sheet, and the most disastrous state of the Company. I joined the Company in August last, and I took the chair in October last year. For the life of me I cannot say why I was asked to take the chair (laughter). The only motive I can think of was that the Board was anxious to get rid of a Director who had joined the Board, and they found it essential in the interests of the Company that that Director should be removed from his position (cries of "Name"). That gentleman failed to pay the calls on his shares, and the Directors availed themselves of the opportunity to declare his seat void at the Board. There are other little irregularities and other matters which I think—I regret to have to make these personal statements—should in the interests of the shareholders be looked to, and I at the risk and sacrifice of my own personal interests looked into them. I found that your money was being squandered in drink and refreshments. I found the most rotten state of things that could possibly be conceived in connection with a Company. I wish to deny all personal motives in saying what I do. My colleagues and I have acted together in the most harmonious way since Christmas, and made gigantic efforts to put the Company on a sound footing; but for obvious reasons—want of capital among them—our efforts have resulted in a most disastrous failure. The Report only goes up to December 31st. Up to that time practically no business had been done by the Company. Hence the lamentable result you see before you. Since Christmas we have done a considerable amount of work; but we have inherited from the old Company a heritage of litigation which has involved us in thousands of pounds outlay. With such an outlay and such limited capital you can imagine the poor prospect of the Company becoming a sound business concern. Before going any further I wish to warn the shareholders against any attempt made by people present to appoint a Committee of Investigation or a Committee of Inquiry. They would do no good. You are doomed to bankruptcy. No Committee of Inquiry can do you any good. Look the matter squarely in the face. We have a heritage of bad debts, and endless litigation from the old Company. We have spent thousands in litigation against Mr. Watt and the Brighton Corporation. Everything we touch seems to go wrong. The sums mentioned in the balance-sheet do not represent half of what we have spent since then (December 31st). Then there is the small capital. We had a capital of £13,000 or £14,000 subscribed to start the Company. I think my co-Directors will agree with me in saying it was a mistake ever to attempt to conduct any business whatever with that capital. I put it to you, was there ever any prospect for the Company under the circumstances which I have mentioned?

Mr. THORNE: What work has the Company done since December?

The CHAIRMAN: It has established an installation at St. Margaret's Mansions, which is a very valuable asset, looked at from that point of view. We have also lighted several flats in the Mansions. Altogether there are about 300 lights. We have lighted the Penny Bank there, and there is a long list of other works which I am ready to show to shareholders. We have also done work for Mr. Theobald, M.P., having lighted

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his place, and given him great satisfaction ; and there are many other jobs which we could have taken had we had the capital in hand. I have, however, given my word that I will not be party to any more money being got out of the shareholders of this Company (hear, hear), and I must join issue with the *Financial News* when it says that in these days electric lighting companies are fairly established and are paying dividends. I ask the *Financial News* to name one electric lighting company that is paying a dividend.

A VOICE : Woodhouse and Rawson.

The CHAIRMAN : What is the dividend ?

The VOICE : 7½ per cent.

The CHAIRMAN : I understand from the Secretary that they have been in liquidation twice. Our difficulty is that we have to compete against men who have some knowledge of electricity, whereas the members of the Board have no practical experience of it. Those men render it impossible for any electric lighting company in the Kingdom to pay a farthing of dividend. I do not think that you will want me to go through the figures of the accounts. Altogether, it is a most disastrous state of things, and we shall not be able to get out of it with any number of Committees of Investigation. If I can reply to any questions I shall be happy to do so.

Dr. F. N. HAWKINS said that according to the Report a part of the business of that meeting was to elect Directors and auditors. How on earth, after the speech of the Chairman, they could be expected to do this he failed to understand. The Chairman had utterly ignored the future. He (the speaker) failed to understand how the Chairman could occupy the chair that day and speak as he had done of the prospects of electric lighting. Why, to listen to the Chairman, one would think it the only business in which there was any competition. Why had the Chairman said nothing about their future ? What do we want with Directors and auditors if it is only fit to wind up ?

The CHAIRMAN : You must have some machinery to wind up.

A VOICE : I move it be wound up.

The CHAIRMAN : You cannot appoint a liquidator to-day. That is a matter for a special meeting.

Dr. HAWKINS : What do you recommend should be done ?

The CHAIRMAN : Gentlemen, this is what I recommend. We have an action pending against Mr. Watt, and in your own interests I think that it would be well to entrust the business of the Company to the present Directors until that action is over. I think you ought not to let the Company fall into the hands of a few who are only interested in finishing it up. My advice is, trust your Directors, and do not be led away by clap-trap. Trust your Directors until this action is over.

Mr. HODGSON, in a lengthy speech, supported the Chairman's views.

A SHAREHOLDER asked when the action was likely to come on ?

The SOLICITOR hoped by the month of August. He doubted if it would be before the long vacation.

Mr. SPICER thought they could do with a far less expensive Board and management.

Mr. GRIFFITHS thought that if the Board would agree to forego their fees it would be a little guarantee of their desire to do well by the Company. When the shareholders were putting nothing into their pockets the Directors ought to be content to do without fees. Their pretensions would not seem so hollow if they would come to some compromise in this respect.

Mr. NEWTON felt the Board ought to be paid. It was not reasonable to ask men to work for nothing, but he regretted that the Board had gone to "loggerheads" amongst themselves. He was glad some of the Board had stuck to their posts.

The CHAIRMAN having explained, in reply to a shareholder, how it was that Mr Swaby received a total salary of £400, and having read the minute under which such payment was made,

Mr. MARKS entered into a very lengthy statement and found fault with many of the remarks and statements of the Chairman ; he alluded to the question of the removal of a Director, and said he did not know till that day that that was the reason the Chairman was elected on the Board. Then in the course of his address the Chairman had asserted that he had found that a large amount of money was squandered in drinks and refreshments. He wished to say that he had never had even a glass of bitter ale at the expense of the Company. The Chairman had also remarked that no business had been done up to December 31st. The volume of business was exceedingly small, but it amounted to £1,674. The remarks of the Chairman had taken him by surprise, and he did not agree with him at all, especially when he said they were doomed to bankruptcy. Dr. Hawkins had naturally asked, "Why on earth do you move resolutions for adoption of the Report and the re-election of Directors if the Company were doomed to bankruptcy." He (the speaker) did not think they were doomed to bankruptcy, and he was in favour of going into liquidation, or in favour of a Committee of Investigation. The course he suggested that the shareholders should adopt was for them to select gentlemen to fill up the vacancies on the Board. He suggested that course because new Directors would have more powers than a Committee of Investigation. Besides, they might appoint gentlemen who were hostile to the Company. So far as he was concerned he should welcome a Committee of Investigation, because the more they inquired into the affairs of the Company the more credit they would give them for the work they had done. What was the cause of their present position ? He would give them a statement of what had taken place. First of all they had to deal with the dissentient shareholders, which had occupied a great deal of their time. Then they had the Watt arbitration. Mr. Watt appeared on the register of the Company as the holder of 7,376 shares ; but the accountant, in going through the books, found that Mr. Watt held certificates for 4,416 shares which the Company had not issued. The Board declined to admit Mr. Watt's right to those shares, and the matter was referred to arbitration, Mr. Whinney being appointed arbitrator ; and he found that Mr. Watt was not entitled to the 4,416 shares. The unfortunate part of the matter was that Mr. Whinney only allowed them £50 for costs, and his own fee came to £48 (laughter). Then, again, they had some difficulty with Messrs. Crisps' account. Messrs. Crisps were indebted to them for £1,500, the payment of which account was refused, and a counterclaim put in for £2,000 for damage sustained by bad workmanship. The Board found that the agreement entered into with Messrs. Crisps showed that the work was to be done in adifferent manner, and they had been obliged ultimately to compromise the matter. When they had those facts before them, could they be surprised that they were not able to give proper attention to the ordinary affairs of the Company ?

The CHAIRMAN replied to Mr. Marks, and especially upon the question of drinks and refreshments. He did not assert that they had been had by the Board, but some one had had them. The petty cash book appalled him ; he found it ran to £10 per week (sensation), and he was told it was for drinks and refreshments at the Law Courts. The works manager (Mr. Tuff) told him so, and that it was customary in Mr. Watt's time ("Shame") There was no doubt those drinks were had.

Mr. TUFF (the works manager) said the refreshments were given to the men who worked late in lieu of overtime money.

The CHAIRMAN repeated that the money had been expended at the Law Courts.

Mr. KLENCK (depositing an enormous bundle of papers on the table) rose in an excited manner to address the meeting.

The CHAIRMAN pointed out that he was not qualified to speak, as he was neither a shareholder or Director.

Mr. NEWTON moved that Mr. Klenck should be heard, which was seconded ; but, after an acrimonious discussion, the motion was put and lost by an overwhelming majority.

Mr. KLENCK : Now I'll go on with my action sharp, then they will hear me.

The CHAIRMAN then put the motion for the adoption of the Report.

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Mr. GUY moved an amendment for the appointment of a Committee of Investigation, which, however, was not seconded.

The original motion was then carried.

The retiring Directors were put up for re-election and approved, and Mr. Hodgson was added to the Board, Mr. Marks announcing that he should retire.

Admiral Inglefield was asked to return to a seat upon the Board. He, however, declined the honour, remarking that he had had more than enough of the Maxim-Weston Company.

The auditors were re-appointed at a fee of 30 guineas.

A SHAREHOLDER asked for another meeting before 12 months.

The CHAIRMAN said they would, he had no doubt, have another in less than six months, when the Watt action was settled.

A vote of thanks having been accorded to the Chairman, he, in returning thanks, said that he regretted he had not made the Company a success. The heritage of litigation and bad work clung to them. He was gratified that that day's meeting had been nothing like so disorderly as he had expected it would be.

The meeting then separated.

The Anglo-Portuguese Telephone Company (Limited).

The adjourned third ordinary general meeting of this Company was held yesterday at the offices, 53, New Broad-street; Sir Alexander Armstrong, K.C.B., F.R.S., presiding.

The SECRETARY (Mr. R. Rodgers) read the notice convening the meeting, and the Report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—In rising to move the adoption of the Directors' Report, I think the first thing I have to do is to congratulate the shareholders on the satisfactory state of the Company generally. There has been a steady increase of income and also of subscribers. The profit on the year's working amounts to £5,361. 16s. 8d. After deducting £600 paid for Debenture interest, and adding £5,827. 19s. 7d. brought forward from 1888, there remains a balance of £10,589. 16s. 3d. to the credit of profit and loss account. Out of this we have paid an interim dividend of 4 per cent., and it is now proposed to write off £1,500 discount on Debentures issued. This has been done by the advice of the auditors, as it cannot be considered an asset of the Company, the Debentures having been issued at a discount. We propose, after paying the interim dividend, to place £6,000 to reserve fund, leaving a balance of £1,089. 16s. 3d. to be carried forward to next year's account, which I think may be considered a very satisfactory state of the Company's affairs. The expenditure on capital account for the year has been large, £9,731. 13s. 10d. This outlay has been entailed in consequence of a great expense attending the erection of a new exchange at Santa Justa, and also because we were obliged to reconstruct many of the existing lines. Hence the expenditure appears large; but it will be gradually diminishing each successive year. The number of paying subscribers in Lisbon is 985, yielding a gross rental of £7,180; while in Oporto the subscribers number 870, giving a gross rental of £4,708, thus making a total income for the past year of £11,888, and showing a steady increase in subscribers of 222, and in value of £1,320 over the preceding year. I may further add that up to the 15th of April the income was £12,204; and since that date there has been a further increase of £316, so that the income at this moment stands at £12,520, which, considering the recent political disturbance in Portugal and the somewhat hostile feeling entertained towards every English enterprise in that country, we must consider satisfactory, and especially inasmuch as there has been no withdrawal of any subscribers except for good reasons. The affairs of the Company, therefore, as far as we can judge, appear to be in a promising state, with every indication of a steadily increasing business. In order to provide for further extensions, we took leave to issue £40,000 Eight per Cent. Second Mortgage Debentures, of which £10,000 were recently offered to subscribers in Portugal; and altogether we consider that this places the Company financially in a very satisfactory condition. There has been a retirement from the Lisbon Board of the Conde de Gouvea and of the Company's legal adviser in Portugal, Dr. Marcal Pacheco. With these few remarks I beg to move—

"*That the Directors' report and accounts ended December 31, 1889, as now presented, be received and adopted.*"

Mr. C. L. W. FITZGERALD seconded the motion, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. FITZGERALD, the retiring Directors, Mr. A. H. Baker and Senhor Jorge O'Neill, were re-elected to their seats at the Board.

The auditors, Messrs. Deloitte, Griffiths and Co., were also re-appointed, and the proceedings terminated.

NEW COMPANIES REGISTERED.

THORNEBURRY MINERS' SAFETY LAMP COMPANY (LIMITED).—This Company has been registered with a capital of £50,000 in £1 shares, to carry on the business, amongst other trades, of oil refiners and of china, glass, metal and general manufacturers, dealers and merchants of and in all apparatus and materials connected with the manufacture or use of lamps.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this Company for the week ended May 2nd amounted to £4,596, and for May 9th to £2,896.

THE LEON COBALT AND COPPER MINING COMPANY (LIMITED).—Prospectuses will be issued to-morrow (Saturday), inviting subscriptions for the capital of a new Company, with the above title, formed to acquire and work valuable mining properties of cobalt and copper ore in Spain. The prospectus states that the properties cover an area of 859 acres, near the town of Villamanin. Mr. A. J. Beardmore, M.E., who has considerable knowledge of the districts in which the mines are situated, in reporting upon the property to be acquired by the Company, states that "the veins are numerous, and the Company has the run upon the lodes for a considerable distance. Rich deposits have invariably been met with, as in the case of 'The Tharsis and Rio Tinto,' as also in the cases of 'The Profunda' and 'The Providencia,' which adjoin the properties of the Leon Company, and are now being worked at a large profit, the ores being very rich, containing from 30 to 40 per cent. of copper and 5 per cent. of cobalt." Some specimens of copper taken from the property have been submitted for analysis, with the result that two specimens from the Company's largest group gave 24⅝ and 29¼ per cent. of copper respectively. A specimen of cobalt ore taken from another portion of the new Company's property, analysed by M. F. Claudet, gives—cobalt, 1·60; metallic copper, 0·37, showing that the ground is cobalt-bearing at a small depth. It may be mentioned that the present price of cobalt is about 8s. per lb. The consulting engineer of the Company is Mr. Edward Jones, M.E., of 4, Tokenhouse-yard, E.C. Some further particulars are given in our advertisement pages, and prospectuses and forms of application can be obtained to-morrow from the Company's bankers, the National Provincial Bank of England, 112, Bishopsgate-street, E.C.; from the brokers, Messrs. Derenburg and Co., 9, Drapers'-gardens, E.C.; and at the offices of the Company, 5, Throgmorton-avenue, London, E.C. The lists open on Saturday, and will close on or before Tuesday, the 20th inst. The shares were dealt in yesterday at a premium.

STOCK EXCHANGE.—Application has been made to the Committee to allow the following to be quoted in the official list:—United River Plate Telephone Company (Limited)—further issue of 3,000 shares, Nos. 55,001 to 58,000.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 2nd, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,515, and for the week ended May 9th, £2,085.

WREXHAM AND DISTRICT ELECTRIC SUPPLY COMPANY (LIMITED).—The first general meeting of this Company took place recently at the offices, No. 12, Queen-street, Wrexham, when an exhaustive report of the proceedings of the Directors since the registration of the Company and the present arrangements for the proposed works was read and adopted unanimously; as also the reports of the engineers engaged.

THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

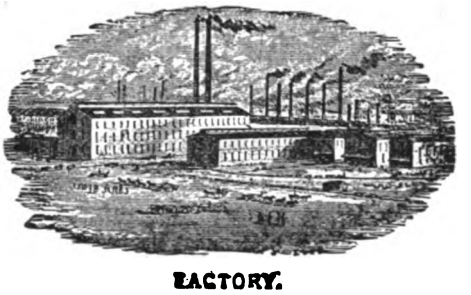
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-60in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 7.	Price Wednesday, May 14.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 14. Highest.	Lowest.
£			**TELEGRAPHS.**			£ s. d.			
1,381,380	Stock	12/6	Anglo-American	50 51	50 51	5 7 10	Jan., Apr., July, Oct.	.. ..	.. ..
2,809,310	Stock	25/0	Do. Preferred	85 86	85 86	6 7 11	,, ,,	86½	85
2,809,310	Stock	..	Do. Deferred	15½ 16	15 15½	..	February	15¼	15
250,000	£100	4%	African Direct, 4 per Cent. Debentures	99 101	98 101	3 19 3	January and July	..	..
130,000	10	3/0	Brazilian Submarine	12¼ 12¾	12 12½	6 0 0	Mar., June, Oct., Dec.	12½	12¼
69,200	100	5%	Do. 5 per Cent. Bonds	101 103	101 103	4 17 1	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	105 108	105 108	4 12 7	June and December	..	..
16,000	10	9/0	Cuba Submarine	11 11½	11 11½	7 16 6	February and August	..	..
6,000	10	10%	Do. Preference 10%	17½ 18½	17½ 18½	5 8 1	,, ,,	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3¾ 4¼	3¾ 4¼	5 3 6	March & September	3¾	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10½ 10⅝	10½ 10⅝	6 14 11	Jan., Apr., July, Oct.	10½	10½
400,000	10	2/6	Eastern	13⅜ 14	13⅜ 13⅝	4 13 8	,, ,,	14	13¾
70,000	10	6%	Do. 6 per Cent. Preference	14¾ 15¼	14¾ 15¼	3 18 8	,, ,,	15¼	15
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	108½	107¼
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	107 110	107 110	4 10 11	February & August	108½	..
250,000	10	6/6	Eastern Extension	14 14¼	13½ 13⅝	5 1 10	Jan., Apr., July, Oct.	14¼	13 11/16
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100 102	100 102	5 17 8	February & August	102	..
91,800	100	5%	Do. 5 per Cent. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	,, ,,	104	..
186,227	10	2/0	Globe Telegraph and Trust	8⅞ 9⅛	8⅝ 8⅞	5 12 8	Jan., Apr., July, Oct.	8 15/16	8⅝
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15⅛	14⅝ 15	4 0 0	,, ,,	14⅝	14⅜
150,000	10	5/0	Great Northern	15½ 16	15½ 16	4 13 6	Jan., July, and April	15⅝	15½
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102 105	102 105	4 15 3	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	38 40	38 40	6 5 0	April and October	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞ 8	7½ 8	5 0 0	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	110 115	110 115	5 4 4	,, ,,	..	..
15,609	£10	3/6	West African	9 10	9 10	..	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	101	100¼
30,000	10	5/0	West Coast of America	6½ 7½	6 7	7 2 10	January and July	7⅛	6
150,000	100	8%	Do. Debentures 8%	117 122	117 122	6 11 2	June and December	118½	118
88,321	10	Nil.	West India and Panama	2⅜ 2⅝	2⅜ 2⅝	..	..	2 5/16	2⅜
34,563	10	12/0	Do. 1st Preference 6%	11½ 12	11½ 12	5 0 0	April and October	11⅞	11½
4,669	10	10/0	Do. 6 per Cent. 2nd Preference	14 15	14 15	4 0 0	..	..	..
64,572	15	6/0	Western and Brazilian	10⅛ 11	10¼ 10⅝	5 12 8	May and November	11	..
26,986	7½	6/0	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	..	..	6⅞	6 7/8
26,986	7½	7/6	Do. 5 per Cent. Deferred	4 4½	4 4½	..	..	4¼	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106 109	106 109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104 107	104 107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99 101	99 101	5 18 10	March & September	..	..
			TELEPHONES.						
224,850	14/0	5%	Consolidated Telephone Const. and Maintenance	5/8 3/4	1 1/16 1 1/8	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼ ⅜	¼ ⅜	4 8 3	Yearly	..	..
386,875	5	3/0	National	5⅝ 5¾	5⅝ 6	..	June and December	6	5 11/16
49,825	5	..	Do. New	5½ 6	5½ 6	..	..	5⅝	5 11/16
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference	12¼ 12¾	12½ 12¾	4 14 1	June and December	12⅝	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference	10 11	10 11	5 9 1	,, ,,	..	..
209,750	1	..	South of England, Ordinary	⅛ ⅜	⅛ ..	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3¼ 3⅝	3¼ 3⅝	6 0 0	..	..	..
55,000	5	2/0	United River Plate	4⅜ 5¼	4⅜ 5	..	January and July	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	2⅜ 2⅝	2⅝ 2⅞	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5¼ 5⅜	5½ 5⅝	..	..	5½	..
42,853	5	..	Westminster Electric Supply	1½ 2	1½ 2	..	..	2	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	2¼ 2⅜	2¼ 2⅜	..	..	2 3/16	..
63,416	2	1/2	Do. Preference	1⅝ 1⅞	1⅝ 1¾	6 8 0	..	1 15/16	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares	5¼ 5⅜	5¼ 5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction	9⅞ 10⅛	9¾ 10⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5 5⅛	5 5⅛	..	..	5⅛	5⅛
20,000	5	..	Fowler-Waring Cables	2¼ 2⅜	2¼ 2⅜	..	..	2 3/16	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18 19	18 19	5 5 3	February & August	18⅜	18¼
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	4½ 5	4⅜ 5⅛	..	..	5¼	5⅛
37,350	12	36/0	Telegraph Construction and Maintenance	44 46	44 46	5 3 11	March and July	45⅞	44⅞
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	..	..	..

JABLOCHKOFF'S

DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 627.—Vol. XXV. FRIDAY, MAY 23, 1890. Price Fourpence.

NOTES.

The announcement which Major Cardew was able to make at the Institution of Electrical Engineers last Thursday that within the next two months a Government Standardising Laboratory on a small scale would commence operations, will be hailed with general satisfaction by the electrical profession. It is now close upon five years since Dr. Fleming first directed attention to this question in a brief but suggestive Paper before the Society of Telegraph Engineers and Electricians. Although the large scheme then sketched is as yet far from realisation, it must, we suppose, be considered a very satisfactory rate of progress for England that scarcely five years have elapsed between the sowing of the seed and the budding of the fruit. Within the next five years, therefore, we may reasonably hope to see a Government Electrical Standardising Laboratory arise, less grandiose but quite as useful as the many similar institutions on the Continent. By that time also the Board of Trade will probably have enlarged their electrical staff, so as to enable those responsible for this important work to devote their whole time to it. The first item on the programme is, we may add, the determination of the true values of the fundamental electrical units; and Major Cardew is hopeful that, with the assistance of Lord Rayleigh and the British Association Committee on Electrical Standards, these determinations will be of unimpeachable accuracy.

The Australasian Colonies have now an opportunity of proving whether their anxiety to reduce the cable rates is tempered with justice towards the Cable Companies. Sir John Pender, on behalf of the principal company concerned, has addressed a communication to the Agents-General of the Australasian Colonies, offering to reduce the rates by nearly one half for all classes of telegrams, provided the Colonies on their part will bear one half of any contingent loss sustained by that reduction, the companies bearing the other half. His proposal is to try the experiment for twelve months; and, if the result is encouraging, to extend the period on terms then to be agreed upon. But even if the arrangement is not extended the companies pledge themselves to establish a tariff not exceeding 8s. per word—against 9s. 4d., the present rate—provided the experiment shows that the companies will derive the same amount of revenue under the reduced tariff as they do under the present one. Nothing, it seems to us, could be fairer than this, or more honourable to the companies who thus voluntarily subject their traffic to a test which will be attended with considerable risk to them, but which cannot fail to benefit the Colonies whatever the result may be. If the Colonial Agents are so sure that reduced rates will prove remunerative here is a chance for them to back their opinion by promptly accepting Sir John Pender's offer.

The attempts which have been made from time to time to construct models illustrating the mechanical actions going on in a dielectric under the action of electric and magnetic forces have not been, as a rule, very successful. At the meeting of the Physical Society on Friday last, Lord Rayleigh exhibited a form of Huyghens' gearing, and showed how it might be made to illustrate the phenomena of mutual induction of electric circuits. The model is certainly the simplest illustration of these phenomena with which we are acquainted.

At the same meeting, Prof. S. P. Thompson described a most interesting series of experiments illustrative of the whole range of Koenig's classical researches on sound. It is a rare privilege to lecture on the life-work of any leader of science, and at the same time to have him present to demonstrate the experiments. No one could have been more happily chosen than Prof. Thompson for the purpose of rendering clear and vivid the intricate phenomena which had to be dealt with. The nature of beats and resultant tones, and the various influences contributing to the character or *timbre* of different sounds, were all fully illustrated in a wonderful series of experiments performed by Dr. Koenig himself with apparatus brought from his own laboratory. In the light of recent electrical researches the study of sound waves is of special interest, as the wave lengths dealt with are of the same order as those occurring in connection with electrical oscillations. In all probability many phenomena familiar to us from our sense of sound will serve to explain some of the more obscure effects arising from the interference and superposition of electrical waves.

The latest American device for the protection of electric lighting circuits from the effects of lightning is due to Mr. C. Wirt. It is well deserving of notice on account of its originality in principle, and also because it is simple in construction, is weatherproof, and requires no inspection. It consists of a pile of metal discs separated by thin ebonite washers. The upper disc is connected with the line by means of a central insulated bolt, and the lower disc goes to earth. The number of washers used will presumably depend on the tension employed in the circuit. In one form there are twenty ebonite gaps, whose

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aggregate thickness does not exceed one-twentieth of an inch. The potential of the flash is sufficient to break down the successive gaps, and thus the lightning can get to earth. The real danger to the circuit, however, arises from the dynamo current maintaining the arc started by the flash, and this is ingeniously avoided by the method of construction adopted. The large masses of metal employed render the starting and maintenance of an arc difficult on account of their cooling effect; but, what is still more important, the dynamo current, in order to do any damage, must maintain several short arcs instead of one long one, and the number of gaps may be so adjusted that the potential needed to do this may far exceed any used in the lighting circuit. It will, however, be necessary to have sufficient thickness of insulation between the central bolt and the metal discs, or the flash will prefer to pass direct from the bolt to the lower disc, and the whole advantage claimed for the lightning guard will be lost. In the diagram which we have seen, the distance in question does not seem sufficiently great.

One of the many consequences of the general adoption of electric traction in the States will apparently be the disappearance, at no distant date, of the tramcar as at present known. Thus the ever progressive West End-street Railway Company of Boston is about to place cars on its lines having from two to three times the passenger-carrying capacity of the old horse cars. Heavier cars, combined with higher speeds, are in their turn bringing the question of more powerful brakes into prominence; and at Boston a Thomson-Houston electric "locomotive" equipped with a vacuum brake worked by a small motor, will shortly come into operation. Before long, in fact, the American tramways bid fair to fully justify their native appellation of "railways," since "trains" of two or three 60 passenger cars drawn by powerful electric locomotives running at a comparatively high speed will contribute their quota to the liveliness of transatlantic streets.

The New World is again to be called in to redress the balance of the old; this time in the matter of electrical nomenclature. At a meeting of the American Meteorological Society last month, it was unanimously resolved that in the naming of electrical units, the services which America had rendered to science had not been properly recognised, and the Society pledged itself to lend every assistance to the furtherance of the claims of Joseph Henry and Benjamin Franklin. At the meeting in question it was not decided what units should be allotted to these claimants. Mr. Francis B. Crocker, however, is of opinion that we should all soon be on speaking terms with the unit of self-induction if we could accustom ourselves to call it Henry, while Franklin, he thinks, might be allowed to appropriate the unit of specific inductive capacity; for "although Franklin knew nothing of inductive capacity, he knew fully as much as Watt knew of watts or Volta of volts." We do not wish in any way to deny these eminent men of science whatever immortality may be conferred upon their names by the decree of some future international electrical nomenclature committee. It will, however, be observed that any attempt to render these names monosyllabic like those of most of their *confrères* by the excision of the ultimate syllable will result in sounds suggestive of ideas quite other than electrical.

In another column will be found a very lively and characteristic account of the Telegraphers' Tournament, which was briefly noticed in our New York correspondent's letter three weeks ago, and on which we made some comments at the time. The description is contributed by Mr. P. B. Delany to the New York *Electrical Engineer*, and will be read with interest by telegraphists all the world over.

Barcelona.—Messrs. Siemens and Halske have applied for permission to erect a central station in Barcelona.

Social.—Sir John Pender entertained Mr. H. M. Stanley and a number of distinguished guests at dinner on Monday last at his house in Arlington-street.

The Tonquin and China Telegraphs.—Intelligence of the opening of the telegraph line connecting Tonquin with China by way of Yunnan has been received in Paris.

Oldenburg.—A company, consisting chiefly of influential manufacturers, has been formed to undertake the lighting of this town by electricity. £75,000 have already been subscribed.

Electric Traction in Italy.—*L'Elettricità* announces that the Board of Public Works has sanctioned the substitution of electricity for steam on the tramway from Firenze to San Domenico.

Birthday Honours.—Amongst the list of Queen's birthday honours we are pleased to note that the honour of knighthood has been conferred on the secretary to the Society of Arts, Mr. H. Trueman Wood.

Execution by Electricity.—The United States Supreme Court has refused the recent application for a writ of habeas corpus in the Kemmler case, but a "writ of error" was heard at Washington on Monday last.

Seizures of Accumulators in France.—In addition to its recent seizure of Laurent-Cély accumulators, the Société Française d'Accumulateurs Électriques has impounded some Julien and some Jarriant accumulators.

The Telephone in Melbourne.—The Australian papers state that shortly direct telephone communication will be established between the head quarters of the Melbourne and Suburban Fire Brigades' Association and every suburb.

Electric Lighting Activity in the West End.—The Highways Committee of the London Council reported on Tuesday that there were applications for the laying of mains in no less than 152 streets, all west of the Law Courts.

Electric Traction.—Several members of the Glasgow Corporation have paid a visit of inspection to the electric tram-cars of the North Metropolitan Tramways Company. They expressed themselves much pleased with what they saw.

Royal Society.—Among the Papers down for reading at the Royal Society yesterday was one "On a Method of Determining the Value of Rapid Variations of a Difference of Potential by means of the Capillary Electrometer," by Mr. G. J. Burch.

Barnsley.—At a meeting of the Town Council, on Tuesday, it was decided that Mr. Bromley Holmes, manager of the Liverpool Electric Supply Company, should be called in to advise and report to the Council upon the tenders submitted for lighting the town by electricity.

The Electric Welding of Shells.—According to *Modern Light and Heat* the United States Government has already given an order for 100,000 shells for the Hotchkiss gun and Shrapnell shells, to be manufactured under the electric welding patent of Lieut. Wood, U.S.N., to which we referred in our issue of May 2nd.

The Swan Patent in Germany.—The two patent suits in Berlin between the Allgemeine Electricitäts Gesellschaft and agents of the Swan Company have been decided in favour

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of the Swan agents. The third suit between the Swan Company itself and the Allgemeine Electricitäts Gesellschaft has not yet been decided.

Silver Bronze.—In a paper recently read before the American Institute of Mining Engineers, Mr. E. H. Cowles described a new high resistance alloy called "silver bronze," which he proposed as a substitute for German silver. Its composition is as follows: Manganese 18, aluminium 1·2, silicium 5, zinc 13, copper 67·6.

Paddington Vestry.—At a meeting of this Vestry, on Tuesday, the Vestry's solicitor was instructed to withdraw the opposition to the application of the Metropolitan Electric Supply Company for a Provisional Order. Some technical objections are, however, taken to these proceedings, and there is to be a meeting on the 29th inst., at which a formal decision will be arrived at.

The Electro-Motor Electrical Works.—At the Heaton Works of Messrs. C. A. Parsons and Co., the whole of the machinery has now for some time past been run by an electro-motor, the current for which is obtained from dynamo machines and engines that are running for test purposes, and the exhaust steam of which is employed to heat the shops. The economy of this arrangement is obvious.

L'Elettricita.—The editor of *l'Elettricità* informs us that he has received a large number of replies in answer to the two questions recently propounded by him. (See *The Electrician*, April 4th.) There was a general consensus of opinion that Hertz's investigations were the most important of recent years, but opinions differed considerably as to what application of electricity would make the greatest progress during 1890.

The Italian Edison Company.—This Company shows a net profit for 1889 of 205,463 lire (£5,125). The principal station at Milan had at the close of the year 565 arcs and 14,807 incandescents at work. This year additional plants are to be put down at Florence, Parma, and the Tarenti Arsenal; and negotiations for a station at Venice are pending. The Company has also taken over the Risalto factory for making electric apparatus.

The Renard Battery and Aerial Navigation.—According to *La Lumière Electrique* Commander Renard's light batteries are not likely to prove of much use for the purpose for which they were mainly designed, namely, aerial navigation. Our contemporary estimates that to maintain a moderately sized balloon in a stationary position for one hour against a breeze of average strength, one ton of Renard batteries would be required.

The Frankfort Exhibition, 1891.—In connection with this Exhibition, some particulars of which will be found in our advertising columns, we understand that it is the intention of the Oerlikon Maschinenfabrik, in conjunction with Messrs. Escher, Wyse, and Co., of Zürich, to equip an electric launch capable of carrying a hundred persons, which it is proposed shall travel up and down the nearest waterways in the interests of the Exhibition. It is also proposed to hold an International Electrical Congress during the Exhibition.

Koenigsberg.—The following are some additional particulars with regard to the municipal central lighting station at Koenigsberg, which, as we mentioned some time ago, is to be worked on the five-wire system. The steam plant comprises two pairs of triple-expansion engines of 100 and 200 horse-power respectively, coupled direct to the dynamos, which are eight in number. The mains are run underground in Monier conduits, and a large battery of Tudor accumulators assists in the supply. This station will shortly come into operation.

Southend.—The Southend Local Board, by a majority of one, have decided to erect works for electric lighting and traction at the new pier; and Messrs. Crompton and Co. have already sent in an estimate for the work. Mr. Watson Smith, resident at Southend, and a representative of Messrs. E. P. Elieson and Smith, has, however, informed the Board, as a ratepayer, that Messrs. Crompton's tender is too high; and in consequence of this the Board have not as yet decided what steps to take in carrying the resolution into effect. Messrs. Crompton's tender involved a total expenditure of about £5,500.

Cardiff.—At the last meeting of the Lighting Committee of the Town Council, a letter was read from the Brush Electrical Engineering Company, asking the Corporation to give its consent to the Company's proposed Provisional Order, and stating that, in the event of the Corporation deciding to obtain its own order, the Brush Company would be prepared to carry out the necessary work. It was resolved that no deputation should be received from the Brush Company until the Committee had decided whether it would recommend the Corporation to go for a Provisional Order, and that a special meeting of the Committee should be called to consider the question of recommending the Corporation to do so.

The Penny Post Jubilee.—At the *conversazione* given at the Guildhall last week by the Corporation in celebration of the Jubilee of the Penny Post, the telegraphic exhibits attracted great attention. The historical exhibits included Cooke and Wheatstone's four-needle telegraph of 1838, and also their double-needle telegraph. The Exchange Telegraph Company showed their column-printing telegraph in operation. Amongst the Post-Office apparatus being manipulated were Morse sounders, working to Penzance; Morse sounders working duplex to Manchester; the Hughes type-printing telegraph, connected with Paris and Berlin; and the Wheatstone automatic. Quadruplex and multiplex working was also shown.

The Halifax-Bermudas Cable.—The steamship "Westmeath," with the Halifax-Bermudas cable on board, left the Thames yesterday afternoon. Capt. A. W. Stiffe will be in charge of the cable-laying operations, and it is expected that telegraphic communication between the two important naval stations of Halifax and Bermuda will be established within the next month or so. The total length of the cable is 874 knots, and its total weight is about 2,000 tons. The Halifax shore end weighs 9·4 tons to the milet. The Bermuda shore end, owing to the presence of coral reefs, has been made especially heavy, and weighs about 19 tons to the mile. The cable, which was manufactured for the Halifax and Bermudas Cable Company by W. T. Henley's Telegraph Works Company, was thoroughly tested before shipment by the Post Office authorities, who pronounced it satisfactory. On Wednesday afternoon Sir Alexander Armstrong, K.C.B. (Chairman), and the Directors of the Halifax and Bermudas Cable Company, with others interested in the success of the Company, went down by special steamer to inspect the "Westmeath" at Greenhithe. We may add that the contractors, Messrs. W. T. Henley's Telegraph Works Company, are just proceeding with the manufacture of another submarine telegraph cable, about 1,000 miles in length.

The Telegraph Conference.—The details of International Telegraphy are regulated by a Conference of delegates appointed by all the Administrations interested, which meets every five years. The last Conference having taken place in 1885 the representatives of the different Governments and of the private companies, mostly submarine, interested in telegraphy, assembled at Paris on May 16th, in the Salle de Manege of the Louvre, when they were addressed by M. Roche, the Minister of Commerce and Industry. Afterwards two Commissions were appointed, one to consider the rules, and the other the tariffs. These have already had several meetings, and amongst other matters it has been decided to adjourn the German proposition, for an uniform rate in Europe of twopence per word, until the next Conference some five or seven years hence. It does not seem to be generally known that all but three or four of the European States lose money by their telegraphs, and had the German proposal been carried this deficit would have been largely increased, while its effect upon the revenues of the Cable Companies would have been almost disastrous. Several other important matters have yet to be discussed, but it is satisfactory to find that the representatives of the Governments recognise the services rendered by the Companies, and show a willingness to arrange the tariff in such a manner that their revenues shall not suffer to any serious extent.

The Telephone in Germany.—According to *Uhlands Wochenschrift* there were in Germany on October 1, 1889, no less than 179 towns with telephone exchanges. There were at the same date 39,876 telephones in use connected by 57,505 kilometres of wire; the average number of communications per diem being 581,839. The following is a list of the towns connected

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by trunk wires, together with the average number of communications exchanged during a day of twelve hours :—

	Kilom.	Communications.
Berlin-Hamburg	290	194
Berlin-Brunswick-Hanover	528	24
Berlin-Magdeburg	177	39
Berlin-Stettin	177	26
Berlin-Halle	165	15
Berlin-Dessau	141	4
Berlin-Leipzig	172	52
Berlin-Breslau	348	86
Berlin-Dresden	232	54
Bremen-Bremerhaven	68	249
Breslau-Beuthen (Silesia)	182	27
Cologne-Bonn	26	363
Frankfort-Mannheim	86	110
Hamburg-Lubeck	66	397
Hamburg-Bremen	151	45
Hamburg-Kiel	95	30
Kiel-Flensburg	122	12
Leipzig-Meeran	65	45

A New Toepler-Holtz Influence Machine.—A new form of the Toepler-Holtz machine has just been brought out by Queen and Co., of Philadelphia. The machine, says the *Scientific American*, is a three-plate machine. The third plate is a perfectly plain glass plate, mounted upon the same axis as the usual revolving plate, and placed behind the fixed plate. Its *modus operandi* is, like many other points in the theory of the Holtz machines, not entirely understood, although there is no doubt but that much of the increased efficiency obtained by its use is due to the screening effect it has upon the other plates; there is also supposed to be a considerable generation of electricity by friction of the plain plate and the air. The advantage of this new form of machine becomes especially marked during moist weather. Another improvement is the form of the electrode which is used. This consists of a metallic disc 2in. or more in diameter, and hollow, so as to have very gradually rounded edges, this preventing any leakage at the edges. Over this disc, separated from it by about $\frac{1}{8}$in., and nearer the other electrode, is fastened a thin disc of vulcanised rubber about $\frac{1}{2}$in. less in diameter. This rubber disc plays the part of the rubber sheet sometimes held between the electrodes, and compels a much higher potential to be established between the two electrodes before a spark can pass. It can be used upon either one or both electrodes, as desired.

An Electric Acoumeter.—With a view of preventing fraud on the part of those who have been drawn for military service, and with whom partial deafness is a very common plea for exemption, Dr. V. Cheval, of Brussels, has brought out a modification of Prof. Hughes's sonometer, which he calls an electric acoumeter. The apparatus consists of three flat coils placed parallel to one another on a graduated rod passing through their axes. The centre coil is the primary and is fixed, the two outer coils are secondaries, and can be slid along the rod. The rod and coils are arranged on a board, on which there are an electrical tuning-fork, a microphone, switches, plugs, and other accessories. The individual whose hearing is to be tested is placed with his back to the apparatus, and has two telephonic receivers fixed tightly over his ears. Various sounds are then produced; the two outer coils being moved gradually away from the centre one until no noise is heard in the telephone receivers. The distance through which the coils have been moved is a measure of the hearing power of the individual. According to Dr. Cheval's investigations a person gifted with a fine sense of hearing ceases to hear the telephonic vibrations of a tuning fork on the left side when the coil is 435mm. distant, and on the right side when the coil has been moved through 535mm. For less sensitive ears the distances are respectively 293 and 401mm. Deafness sufficiently pronounced to exempt from military service is represented by a distance of 100mm. These distances, of course, are not absolute, and only refer to the particular apparatus employed in these researches.

The Electrical "Ageing" of Alcohol.—After the crude material has been obtained, there are two stages in the process of preparing alcohol, namely, the rectification and the ageing. The method usually adopted for the latter purpose is to allow the spirit to remain several years in badly-corked barrels. This naturally involves the storage of large quantities of spirit, and to overcome this disadvantage M. Teillard has adopted the Broyer-Petit electro-chemical method at his distillery at Tournus. The principle of this process is to hasten the oxidation of the alcohol by exposing it to the action of ozone. To prepare the ozone two spirals of aluminium are arranged, one outside and one inside a perforated glass tube 1cm. in diameter and 45 cm. long; around this tube is another one. The ends of the two spirals pass through the outer tube, and are connected to the terminals of an induction coil. Oxygen is sent through the inner tube, and is exposed to the influence of a silent discharge between the two spirals. Great care is required in this operation. No sparks must occur, and the temperature of the apparatus must not exceed 15° to 20° C., or the ozone will be destroyed. In actual practice the oxygen is passed through three such tubes in succession, the induction coils being worked by a dynamo giving 3 volts and 6 amperes. By this means 10 cubic ms. (353 cubic feet) of oxygen is ozonised per hour. In addition to the dynamo, engine, and boiler, the complete installation comprises an oxygen gasometer of 20 cubic ms. capacity, six spirit vats, an oxygen pump, and an alcohol pump. All taps must be of wood, all tubes of glass, all plugs of cork, and the interior of the vats completely stripped of metal, owing to the energetic action of the ozone. In carrying out the process six vats are first filled with spirit. Oxygen is then passed from the gasometer over chloride of calcium to dry it, and is then passed through the ozonisers to a flask with three tubulatures, and thence through the six vats in succession to the condenser, where any vapour of alcohol taken up is deposited. The gas is then regenerated and used afresh. The volume of ozone required is about six times the volume of the alcohol treated, and the time required varies from five to six hours. Alcohol so treated is then stored in barrels, and after five or six months is ready for use.

The Keswick Water-power Electric Light Station.—At the last meeting of the Institution of Civil Engineers a Paper, by Messrs. W. P. James Fawcus and Edw. W. Cowan, was read on this the first attempt to utilise water-power in this country for the purposes of a public supply of electric light. The alternating-current transformer system is employed, and the station is on the banks of the River Greta, about three-quarters of a mile from Keswick, where there is a head of 20ft. The rent paid for the water is 10s. per horse-power per annum. Taking the number of horse-power hours required per annum as 100,000 for the present output of the station from a 50 horse-power turbine, the cost per horse-power came out as 0·06d. On the other hand, taking the price of steam coal at 15s. per ton, and the quantity burnt per horse-power per hour as 6lb., the cost per horse-power hour came to 0·48d. As there is, however, a possibility of partial failure of the water-supply during extreme drought in summer, steam is provided in addition. The turbine is a "Victor," of a mixed-flow type; the wheel is 20in. in diameter, and its speed is 273 revolutions per minute. The engine is a Westinghouse of simple type, having two single-acting cylinders, 10in. diameter by 9in. stroke; at 350 revolutions per minute, with 80lb. of steam, it gives 50·11 B.H.P. The alternator, designed by Mr. Gisbert Kapp, and manufactured by Messrs. Johnson and Phillips, the contractors for the electrical plant, is a 30-kilowatt (15 amperes 2,000 volts) machine. It runs at 750 revolutions, and the frequency is 75. The resistance of the armature, after working some hours, has been found to be 7 ohms. The total resistance of the field, after working some hours, is 11·2 ohms. The mains are carried overhead, and special attention has been paid to obtaining good insulation at the supports by means of oil insulators. The sizes of the mains are fixed for a current density of 500 amperes to the square inch. The fall of potential between the generating station and the town is only slightly above 1 per cent at full load. Steel suspension strand is used for supporting the mains for all circuits. One short run of underground mains on the Brooks fluid system is being tried. A series of experiments have been made to test the efficiency of the machinery, with the result that the total efficiency of the generating plant at the station came out at about 40 per cent. at $\frac{1}{4}$ full load, and over 70 per cent. at full load.

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MAGNETISM IN IRON AND OTHER METALS.*—XVIII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 31.*)

§ 78. **Effects of Hysteresis.**—Figs. 43 and 44 give further illustrations of the effects of magnetic hysteresis in causing loops to be formed on the curves of magnetisation when the magnetising force experiences any cyclic change. Fig. 43 refers to a ballistic test of a ring of very soft annealed iron. It shows, in addition to the large loop produced by reversal of the magnetising force, a smaller loop produced by its removal and re-application, and also two small loops formed by pausing at points on the steep part of the demagnetisation

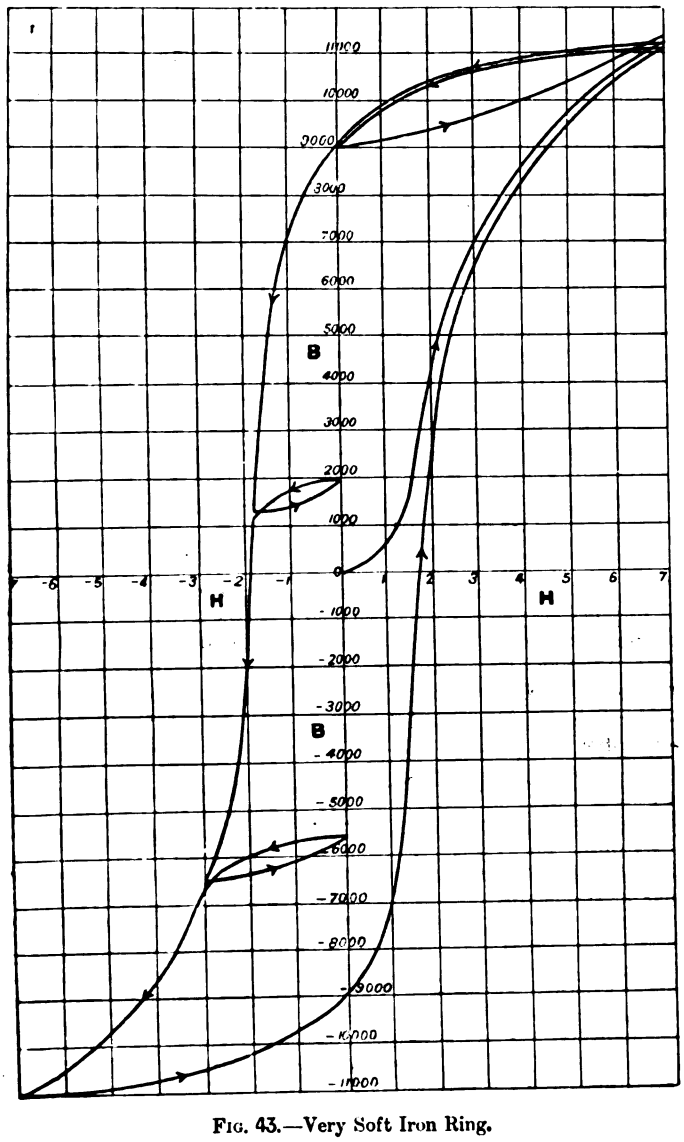

FIG. 43.—Very Soft Iron Ring.

curve and removing and re-applying the force there. In Fig. 44 the effects are shown of removing and re-applying the force at a number of successive points during the magnetisation of a long wire of soft annealed iron. Many of the experiments have shown that similar loops are formed by partial instead of complete withdrawal of magnetising force, followed its re-application, and that steel, nickel, and cobalt yield results of the same kind. The form of the curves is found to be not materially different whether the changes of magnetising force are made to occur at a moderate rate or excessively slowly. In other words, the hysteresis shown by these loops is persistent with regard to time. Even prolonged pauses, during which the magnetising force is kept constant at values midway between the two extremes of the cycle, do not cause the differences of magnetism due to hysteresis to disappear, or even to become sensibly lessened.

It is at the steep parts of the magnetisation curve that the effects of hysteresis are most apparent. Starting from a point such as a (Fig. 44), removal and re-application of the force augment the magnetism; this is because the acquisition of magnetism in the original ascending process was retarded by hysteresis, with the result that any species of disturbance (such as the renewal and re-application of the force) causes an increase. If we were to repeat the cyclic disturbance by again removing and re-applying the same force, we should find a small further increase; and it is only after several repetitions of the cycle of magnetising force that its magnetic effects become strictly cyclic.

Every loop in these diagrams shows that whenever the process of altering the magnetic force is reversed from a process of increment to a process of decrement, or *vice versâ*, the magnetism begins to change very slowly relatively to the change of **H**, no matter how fast it may have been changing (in the opposite direction) immediately before. So much is this the case that the curves, when drawn to a scale so small as the scale of these diagrams, appear to start off tangent to the horizontal line whenever the change of **H** is reversed in sign. It will be shown, however, in a later chapter that the initial gradient

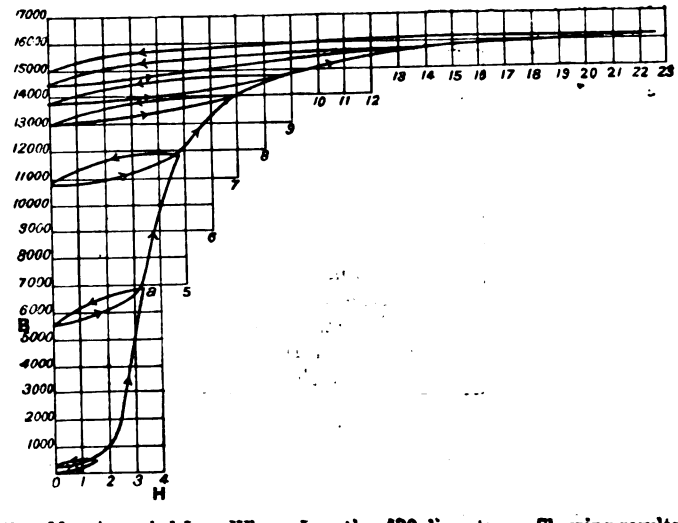

FIG. 44.—Annealed Iron Wire. Length = 480 diameters. Showing results of removing and reapplying the magnetising force.

of these curves is not really zero, but a small positive quantity. At the steepest part of the great cycle in Fig. 43 the value of $\frac{d\mathbf{B}}{d\mathbf{H}}$ is no less than 14,500; in the initial slope of one of the small loops $\frac{d\mathbf{B}}{d\mathbf{H}}$ is probably not more than 150. In other words, if during the reversal of magnetism we pause at the steepest part of the curve and begin to remove the magnetic force, the gradient of the new curve is about 100 times less steep than that of the curve from which it springs.

An obvious effect of hysteresis is to prevent any simple relation from existing between **H** and **B**, or **H** and **I**. To specify the magnetisation, we must know not only what value the magnetic force actually has, but what changes it has undergone in reaching that value. Associated with any one value of the force there is a wide range of possible values of **B** or of **I**. By a suitable choice of processes in the application and removal of **H**, we may carry the magnetisation curve through any point whatever within the wide area enclosed between the curves which correspond to reversal and re-reversal of a strong magnetising force. Hence the definition of permeability, as the ratio of **B** to **H**, or the definition of susceptibility, as the ratio of **I** to **H** requires to be limited (as was indicated in § 21) by the conditions (1) that the piece is neutral to begin with; and (2) that the magnetising force, with reference to which the permeability or susceptibility is expressed, is to be applied by simple increment from zero, without passing at any stage from higher to lower values

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Not only may the magnetisation curve be made to pass through any specified point in the area enclosed by the large reversal curves, but it may have more than one gradient in passing through the point. The following is an interesting example of this effect of hysteresis. Suppose that on the descending limb, P Q, of the main reversal cycle we have stopped increasing the negative magnetic force at a point Q, so chosen that when the force is removed the curve Q O passes through the origin. When the process Q O is completed, the piece has no magnetism, and it lies in a field of no force. Tested in any ordinary way it might seem to be in a perfectly neutral state; but its condition is far from being the same as that of a virgin piece, or from that of a piece which has been made neutral by the process of "demagnetising by reversals." Such pieces show no directional difference; their susceptibility is the same whether the first magnetising force be positive or negative. But in this case a positive force would give the curve O R, which is a continuation of Q O; whereas a negative force would give the wholly different curve O S. The initial susceptibility in the former case is very much greater than in the latter. In consequence of hysteresis the piece, although destitute of actual magnetism and not acted on by any magnetising force, retains traces of the magnetic changes it has passed through, which cause it to show a striking want of directional symmetry when it is subsequently magnetised in one or the other direction.

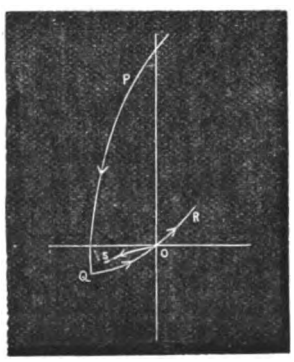

Fig. 45.

Though there is no external evidence that the piece is anything but neutral, it is much more ready to take magnetism of an opposite sign from that which it last held than to take magnetism of the same sign.

(To be continued.)

ON PROF. ELIHU THOMSON'S ELECTRO-MAGNETIC INDUCTION EXPERIMENTS.*

By J. A. Fleming, M.A., D.Sc., M.I.E.E., Professor of Electrical Engineering in University College, London.

(Continued from page 35.)

We have already seen that in an alternating field the electro-dynamic impulses so experienced by the disc or ring are alternately attractive and impulsive, and that when the circuit possesses a sensible self-induction, the repulsive impulses overpower the attractive ones, and their repetition constitutes a repulsive force. Before adding a few more words of explanation, permit me to show you some of these electro-dynamic repulsions produced by an alternating electro-magnet. Here is a copper ring, and I lay it upon the top of this electro-magnet, having a divided iron core and excited by a powerful alternating current. On energising the magnet the ring jumps up in the air (*see* Fig. 9). If a copper plate is hung like a scale pan from a balanced beam, and placed over the magnetic pole, it gives evidence of being strongly repelled the moment we pass the current through the coils of the magnet (*see* Fig. 10). Instead of employing copper rings or copper plates, we can use closed coils of thick wire, either insulated or not. If, however, our plates or rings have a radial slit made in them, or if our coils of wire are not closed-circuit coils, all the effects vanish.

So strong is this repulsion with proper appliances, that light copper rings tethered by strings may be held suspended in the air against the force of gravity, the upward electro-magnetic repulsion overcoming their weight, and holding them, like Mahomet's fabled coffin, floating in the air (*see* Fig. 11). In cases where we are dealing only with impulsive effects, aluminium rings or discs give most marked results, because aluminium has the highest conductivity per unit of mass; but in the cases like those just considered, where what is required is the greatest force effect, copper or silver gives a better

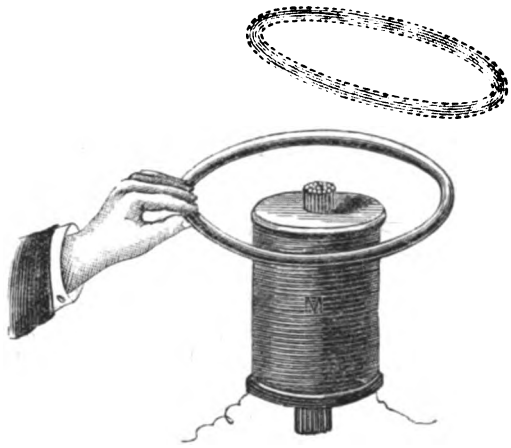

Fig. 9.

result than aluminium, because they have the highest conductivity per unit of volume. In Mr. Boys' experiments, if I remember rightly, he found aluminium the best to employ. In these cases of

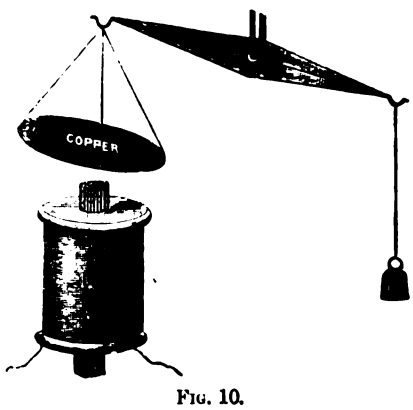

Fig. 10.

electro-dynamic repulsion the force effect depends essentially upon the lag of the induced current or its retardation in phase behind that of the inducing field, and, other things being equal, this is

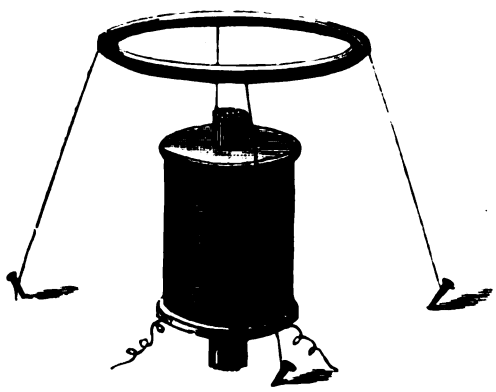

Fig. 11.

proportional to the conductivity of the circuit. I will pass before your view a series of diagrams intended to represent various cases and modes of production of these repulsive effects, giving you descriptions of them in Prof. Elihu Thomson's own words. He says:—

"This preponderating repulsive effect may be utilised or may show its presence by producing movement or pressure in a given

* A Paper read before the Society of Arts, May 14, 1890.

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direction, by producing angular deflection as of a pivoted body, or by producing continuous rotation in a properly organised structure.

"In Fig. 12, C is a coil traversed by alternating currents, B is a copper case or tube surrounding it, but not exactly over its centre. The copper tube B is fairly massive and is the seat of heavy induced currents. There is a preponderance of repulsive action tending to force the two conductors apart in an axial line. The part B may be replaced by concentric tubes slid one in the other, or by a pile of flat rings, or by a closed coil of coarse or fine wire insulated or not. If the coil C, or primary coil, is provided with

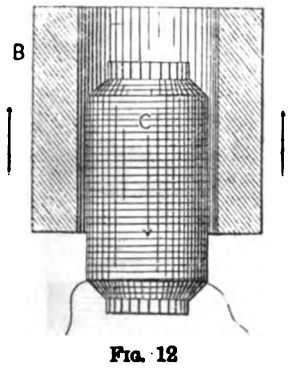

FIG. 12

an iron core such as a bundle of fine iron wires, the effects are greatly increased in intensity, and the repulsion with a strong primary current may become quite vigorous, many pounds of thrust being producible by apparatus of quite moderate size.

"The forms and relations of the two parts C and B may be greatly modified, with the general result of a preponderance of repulsive action when the alternating currents circulate.

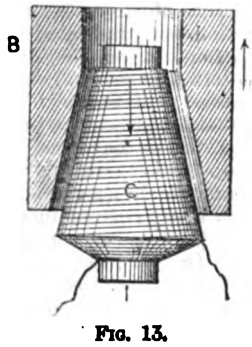

FIG. 13.

"Fig. 13 shows the part, B, of an internally tapered or coned form, and C, of an externally coned form, wound on an iron wire bundle, I. The action in Fig. 12 may be said to be analogous to that of a plain solenoid with its core, except that repulsion, and not attraction, is produced, while that of Fig. 13 is more like the action of tapered or conically-wound solenoids and taper cores. Of course, it is unnecessary that both be tapered. The effect of such shaping is simply to modify the range of action and the amount of repulsive effort existing at different parts of the range.

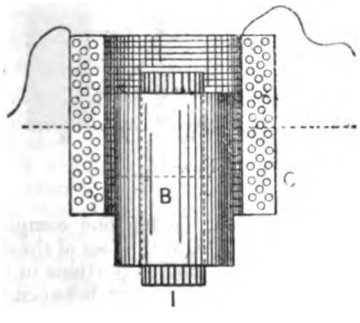

FIG. 14.

"In Fig. 14 the arrangement is modified so that the coil C is outside, and the closed band or circuit B inside and around the core I. Electro-inductive repulsion is produced as before.

"It will be evident that the repulsive actions will not be mechanically manifested by axial movement or effort, when the electrical middles of the coils or circuits are coincident. In cylindrical coils, in which the current is uniformly distributed through all the parts of the conductor section, what I here term the electrical middle, or the centre of gravity of the ampere turns of the coils, will be the plane at right angles to its axis at its middle, that of B and C in Fig. 14 being indicated by a dotted line. To repeat, then, when the centres or centre planes of the conductors, Fig. 14 coincide, no indication of electro-inductive repulsion is given, because it is mutually balanced in all directions; but when the coils are displaced, a repulsion is manifested, which reaches a maximum at a position depending on the peculiarities of proportion and distribution of current at any time in the two circuits or conductors.

"In Fig. 15, B represents a copper ring, and C an annular coil placed parallel thereto; and an iron core or wire bundle placed in

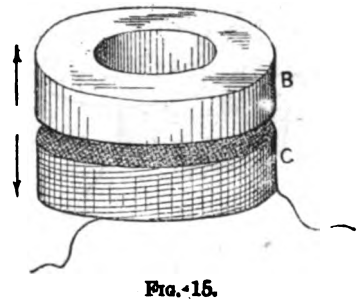

FIG. 15.

the common axis of the two coils shows the repulsive action when an alternating current is passed through C. B may be simply a disc or plate of any form, without greatly affecting the nature of the action produced. It may also be composed of a pile of copper washers or a coil of wire, as before indicated.

"An arrangement of parts somewhat analogous to that of a horseshoe electro-magnet and armature is shown in Fig. 16. The alternating-current coils C C′ are wound upon an iron wire bundle

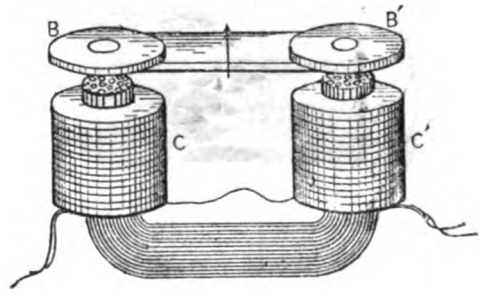

FIG. 16.

bent into U-form, and opposite its poles is placed a pair of thick copper discs, B B′, which are attracted and repelled, but with an excess of repulsion depending on their form, thickness, &c.

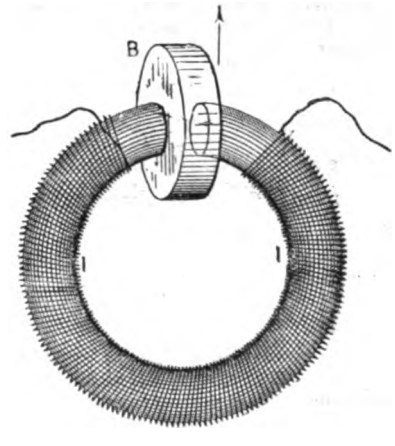

FIG. 17.

"If the iron core takes the form of that shown by I I, Fig. 17, such as a cut ring with the coil C wound thereon, the insertion of a heavy copper plate, B, into the slot or divided portion of the ring will be opposed by a repulsive effort when alternating currents pass in C. This was the first form of device in which I noticed the

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phenomenon of repulsive preponderance in question. The tendency is to thrust the plate B out of the slot in the ring, excepting only when its centre is coincident with the magnetic axis joining the poles of the ring between which B is placed.

"If the axes of the conductors, Fig. 15, are not coincident, but displaced, as in Fig. 18, then, besides a simple repulsion apart, there is a lateral component or tendency as indicated by the arrows. Akin to this is the experiment illustrated in Fig. 19. Here the closed conductor B is placed with its plane at right angles to that of C, wound on a wire bundle. The part B tends to move toward the centre of the coil C, so that its axis will be in the middle plane of C, traverse to the core, as indicated by the dotted line. This leads us at once to another class of actions, *i.e.*, deflective actions.

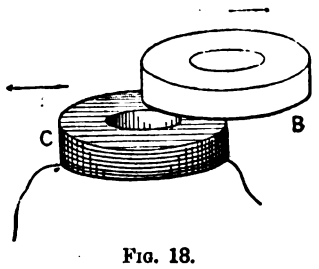

FIG. 18.

"When one of the conductors, as B, Fig. 20, is comp sed of a disc, or, better, of a pile of thin copper discs, or of a closed coil of wire, is mounted on an axis X transverse to the axis of coil C, through which coil the alternating current passes, a deflection of B to the position indicated by dotted lines will take place, unless the plane of B is at the start exactly coincident with that of C. If slightly

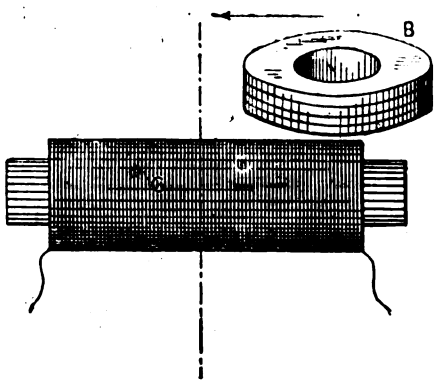

FIG. 19.

inclined at the start, deflection will be caused as stated. It matters not whether the coil C incloses the part B or be inclosed by it, or whether the coil C be pivoted and B fixed, or both be pivoted. In Fig. 21 the coil C surrounds an iron wire core and B is pivoted above it as shown. It is deflected, as before, to the position indicated in dotted lines.*

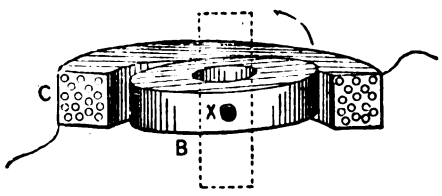

FIG. 20.

"It is important to remark here that, in cases where deflection are to be obtained as in Figs. 20 and 21, B had best be made of a pile of thin washers or a closed coil of insulated wire, instead of a solid ring. This avoids the lessening of effect which would come from the induction of currents in the ring B in other directions than parallel to its circumference."

* This deflection by an alternating current of a copper disc suspended within a coil with its plane inclined to the plane of the coils I myself noticed independently in March, 1887, and subsequently described a copper disc galvanoscope for alternating currents based on this fact (see *The Electrician*, May 6, 1887). I did not at the time know how thoroughly Prof. Thomson had explored the phenomena, but the substantial explanation of it had already occurred to me.

Returning for a moment to the theory of these repulsive and deflective actions, it will repay us to consider it in the form placed before us by Prof. Thomson, in his first Paper on the subject, read before the American Institute of Electrical Engineers, May 18, 1887. He says:—"It may be stated as certainly true that were the induced currents in the closed conductor unaffected by any self-induction, the only phenomena exhibited would be alternate equal attractions and repulsions, because currents would be induced in opposite directions to that of the primary current when the latter current was changing from zero to maximum positive or negative current, so producing repulsion; and would be induced in the same direction when changing from maximum positive or negative value to zero, so producing attraction.

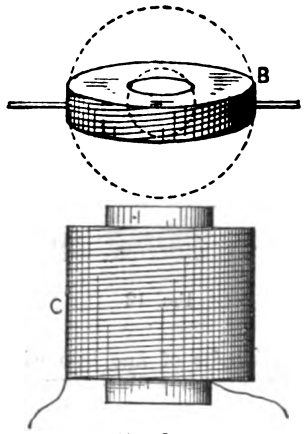

FIG. 21

"This condition can be illustrated by a diagram, Fig. 22. Here the lines of zero current are the horizontal straight lines. The wavy lines represent the variations of current strength in each conductor, the current in one direction being indicated by that portion of the curve above the zero line, and in the other direction by that portion below it. The vertical dotted lines simply mark off corresponding portions of phase or succession of times.

"Here it will be seen that in the positive primary current descending from m, its maximum, to the zero line, the secondary current has risen from its zero to m^1, its maximum. Attraction will therefore ensue, for the currents are in the same direction in the two conductors. When the primary current increases from zero to its negative maximum n, the positive current in the secondary closed circuit will be decreasing from m^1, its positive maximum, to zero; but, as the currents are in opposite directions, repulsion will occur. These actions of attraction and repulsion will be reproduced continually, there being a repulsion, then an attraction, then a repul-

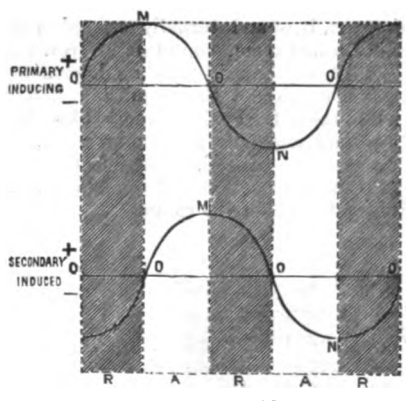

FIG. 22.

sion, and again an attraction, during one complete wave of the primary current. The letters r, a, at the foot of the diagram, Fig. 22, indicate this succession. (The shaded portions in the diagrams represent the time during which the force between the primary and secondary circuits is a repulsive force.)

"In reality, however, the effects of self-induction in causing a lag, shift, or retardation of phase in the secondary current, will considerably modify the results, and especially so when the secondary conductor is constructed so as to give to such self-induction a large value. In other words, the maxima of the primary or inducing current will no longer be found coincident with the zero points of the secondary currents. The effect will be the same as if the line representing the wave of the secondary current in Fig. 22 had

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been shifted forward to a greater or less extent. This is indicated in diagram, Fig. 23. It gives, doubtless, an exaggerated view of the action, though from the effects of repulsion which I have produced I should say it is by no means an unrealisable condition.

"It will be noticed that the period during which the currents are opposite, and during which repulsion can take place, is lengthened at the expense of the period during which the currents are in the right direction for attractive action. These differing periods are marked *r*, *a*, &c., or the period during which *repulsion* exists is from the zero of the primary or inducing current to the succeeding zero of the secondary or induced current; and the period during which *attraction* exists is from the zero of the induced current to the zero of inducing current. (It will be seen that the shaded portions in Diagram 23 have been widened out at the expense of the unshaded parts.)

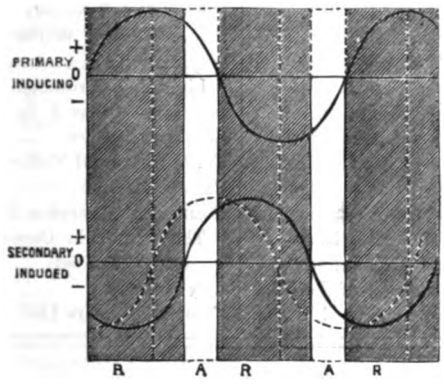


FIG. 23.

"But far more important still in giving prominence to the repulsive effect than this difference of effective period is the fact that during the period of repulsion both the inducing and induced currents have their greatest values, while during the period of attraction the currents are of small amounts comparatively. This condition may be otherwise expressed by saying that the period during which repulsion occurs includes all the maxima of current, while the period of attraction includes no maxima. There is then a *repulsion due to the summative effects of strong opposite currents* for a *lengthened period* against an *attraction* due to the summative effects of *weak currents* of the *same direction* during a *shortened period*, the resultant effect being a greatly *preponderating* repulsion.

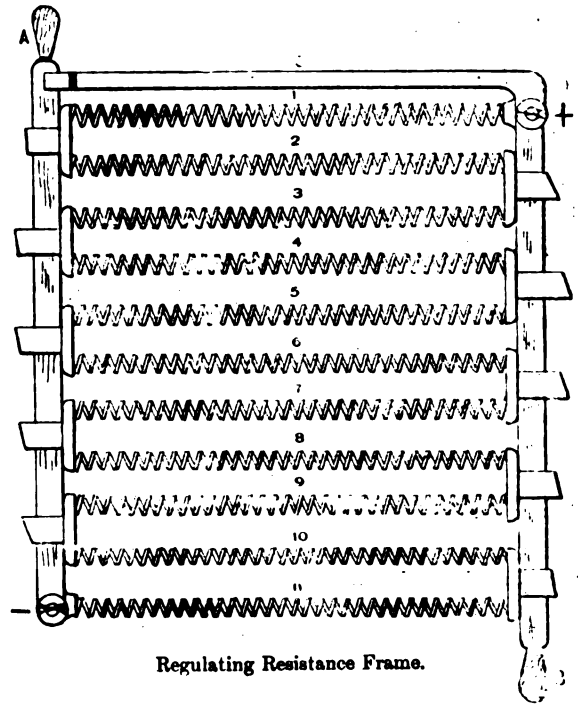
"It is now not difficult to understand all the actions before described as obtained with the varied relations of coils, magnetic fields and closed circuits. It will be easily understood, also, that an alternating-magnetic field is in all respects the same as an alternating-current coil in producing repulsion on the closed conductor, because the repulsions between the two conductors are the result of magnetic repulsions arising from opposing fields produced by the coils when the currents are of opposite directions in them."

(To be continued.)

A REGULATING RESISTANCE FRAME.

In an article on "Regulators," recently contributed to the *Electrical World*, Mr. Albert B. Herrick describes the following simple form of regulating resistance frame:—

When the lever A is in the position shown in the figure, the resistance coils are short-circuited from the positive pole through the metallic bar C, and then through lever, A, to the negative pole. When the lever A is withdrawn from contact with bar, C, all the resistance-coils are then in multiple arc between the positive and negative poles. In this position we have the maximum ampere-carrying capacity and the least resistance. The resistance is increased by still further withdrawing the bar A, when the coils 1 and 2 will be cut out and the resistance of the regulator increased. The resistance can be still further increased by steps until lever A, in succession, is withdrawn from all the contacts, when we will have only spiral No. 11 in circuit. The resistance may then be increased by withdrawing lever B, and the spirals placed in series. By this arrangement we have obtained a regulator having the maximum ampere capacity on the first step, with all the spirals in multiple, and a maximum resistance on the last step, with all spirals in series. If the resistance of spiral 11 is so proportioned that it will not take more current than the maximum when lever A is removed, all the rest of the regulator will have ample capacity. Such a combination only gives 12 possible steps, but a more complicated switch could be designed which would multiple series the spirals, and which would give us a greater number of combinations with these spirals, so that any desired number of steps could be produced between the maximum ampere capacity and maximum



Regulating Resistance Frame.

resistance. In any regulator energy must be wasted to produce certain variations in the current. From the point of economy they are abominable, but they are as necessary to the electrician as the valve is to the engineer.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, May 23rd.

CITY AND GUILDS OF LONDON INSTITUTE.
OLD STUDENTS' ASSOCIATION.

8 p.m. Smoking Concert at Anderton's Hotel, Fleet-street.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Manners and Customs of the Torres Straits Islanders." By Prof. A. C. HADDON, M.A.

SATURDAY, May 24th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Recent Excavations in Greece." By CHARLES WALDENSTEIN, Ph.D.

TUESDAY, May 27th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Natural History of Society." By ANDREW LANG.

INSTITUTE OF MARINE ENGINEERS.

7:30 p.m. Paper to be read: "Ventilation of Steamships." By D. G. HOEY.

THURSDAY, May 29th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Flame and Explosives." By Prof. DEWAR, M.A., F.R.S.

FRIDAY, May 30th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Astronomical Telescopes." By A. A. COMMON, F.R.S.

SATURDAY, MAY 31st.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Ballad Music of the West of England." By the Rev. S. BARING-GOULD, M.A.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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THE POLICY OF THE BOARD OF TRADE.

Some curiosity was evinced as to what Major CARDEW would have to say in his Paper announced to be read last week before the Institution of Electrical Engineers on "The Treatment, Regulation, and Control of Electric Lighting by the Legislature and the Board of Trade." The title was a comprehensive one, and manifestly gave scope for a wide discussion. It could hardly have been expected that he would be in a position to unfold new developments of Board of Trade policy, or disclose secrets hitherto locked up in pigeon-holes at Whitehall; and if any one had looked for such a thing the illusion must have been immediately dispelled by the author's opening remarks. Major CARDEW not only had no message to communicate, but he deprecated even a discussion of the past policy of the Board. In the face of this prohibition it was difficult to say what there was to be discussed; and the proceedings became almost devoid of interest. For the benefit of those who have never had the leisure or inclination to read through the two not very long Acts which deal with electric lighting, and the more tedious Model Forms of Provisional Orders, Major CARDEW gave a convenient summary of these documents, but no information which was otherwise beyond their reach. The subject uppermost in the minds of those present, and which the title of the Paper would obviously suggest to every one at the present time, was the transfer clause which the Board of Trade have inserted in the new Provisional Orders to be granted to Local Authorities. This, however, being most essentially a question of policy, was, under Major CARDEW'S conditions, excluded from the field of discussion. Since these columns are not fettered in the same way, we propose to offer some remarks on the subject, and to point out why we think the recent policy of the Board of Trade in respect of the Provisional Orders about to be presented to Parliament is open to very serious criticism, and demands at this moment the particular attention of all who are interested in the future of electric lighting.

There are certain well-defined limits to legislation by Provisional Order which appear to have been over-stepped by the Board of Trade in the present instance. A Provisional Order is a very convenient method of applying a general Act to a

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particular case, but it is not applicable to original legislation. Where private rights have to be interfered with by the exercise of compulsory powers of taking lands, &c., or where authority is required to do anything which is not sanctioned by the general Act, the proceedings must be by a Bill in Parliament. No doubt, as a matter of mere machinery, a Provisional Order, when embodied in the confirming Act which is necessary to its validity, becomes a part of the law of the land. But Parliament is apt not to look very carefully into the contents of a Provisional Order which is brought up for confirmation. The Order comes before Parliament endorsed with a certificate, so to speak, of the Government Department which has granted it, that it contains all which the general Act requires, and nothing more than the law has already authorised to be inserted in an Order of the kind. The Electric Lighting Acts have undoubtedly left an unusual amount of details to be filled in at the discretion of the Board of Trade; but certain broad principles are laid down which the latitude granted in the treatment of details does not permit to be broken through; still less can matters foreign to the general principles of law be introduced. Now, it is a thoroughly-established principle of law that when Parliament has conferred special rights, coupled with corresponding obligations, these rights and obligations cannot be transferred by the statutory owner without the express sanction of the Legislature. A concession, which is hawked about and sold to the highest bidder, has hitherto been entirely unknown in this country, and the very name has a foreign sound about it. If we are now to see this kind of thing introduced in England, it is certainly an important development of our commercial policy, and a matter which one would hardly expect to meet with for the first time in a Provisional Order.

We noticed with some surprise a remark which the President of the Board of Trade is reported to have made in the course of the proceedings at a recent deputation: it was that the Board have the power to sanction transfers by Local Authorities. If these words are to be construed quite literally, probably no one would care to contest such a statement; but, if the President meant that his sanction would enable a Local Authority to transfer the obligations it has incurred under a Provisional Order, then the statement is certainly opposed to what, so far as we can ascertain, is the unanimous opinion of the lawyers who have considered the question. If, as we believe is unquestionably the case, the Electric Lighting Acts give no power to undertakers to transfer their liabilities, either with or without the consent of the Board of Trade, then it is an unconstitutional act to send up for confirmation by Parliament a Provisional Order which confers this power. The principle involved is, we think, of vital importance, particularly having regard to the terms of the clause as it appears in the Model Form of Order recently issued. No provision whatever is made for any one being heard in opposition to the transfer; and even if such a provision had been added, the safeguards afforded by an investigation before a Parliamentary Committee, where witnesses can be summoned and examined on oath, would still be wholly absent. The result of such an enactment, if it is allowed to be smuggled through Parliament in the unconstitutional guise of a clause in a Provisional Order, will, we believe, be most disastrous to the interests of electric lighting.

Local Authorities, who, in too many cases are notoriously interested in stifling electric lighting schemes, will hesitate no longer about getting the key of the situation into their own hands. The transfer clause will place the game in their hands; and they cannot be expected to decline so tempting an invitation to play at "heads I win, tails you lose." Having acquired a Provisional Order—or concession, as we shall have to call it in future—they will sit still as long as they can do so with safety, or until they can drive a lucrative bargain, and then transfer the whole undertaking on onerous terms, which will involve an early bankruptcy to the purchasers. It must not be supposed that this is an imaginary picture. An enormous impetus has been recently given to every branch of industry connected with electric lighting, which, when new schemes receive a check, will result in over-production. Manufacturers must find a market for their goods; and we cannot doubt that this will result in the fostering of unstable concerns, which will only too readily fall victims to the demands of Local Authorities.

Arguments are not wanting against Local Authorities being allowed to meddle at all in commercial transactions; but seeing that more than one-third of the total capital invested in gas-works is already under their control, it is too late to discuss this policy, which has, moreover, been expressly recognised by the Electric Lighting Acts. Parliament has declared that electric lighting shall be carried on under certain prescribed conditions, and that Local Authorities may, if they please, become undertakers in accordance with these conditions; but this is a wholly different thing to saying that they shall have concessions to traffic with, and that electric lighting shall thenceforward be carried on, not on the terms prescribed by Parliament, but on such terms as the Local Authority of each district may dictate. Such a system as this has never received any recognition whatever by Parliament, either in connection with electric lighting or anything else. It is absolutely a new principle, and the effect of it will be to stultify if not repeal a material portion of the Acts. Is such a result as this to be brought about by a mere confirmation of Provisional Orders? Is the hard-earned 42-years' term, which was granted by the Act of 1888, to be sacrificed without a struggle by the mere dictum of the Board of Trade, as a sop to influential Local Authorities? So important a change of the law, we maintain, ought not to be carried out without the fullest consideration of Parliament; and we think that the electrical trades will be wise to exert all their influence with members to secure that the Bill for confirming these Provisional Orders shall at least not pass unchallenged.

REVIEWS.

"Notes on Electric Lighting." By the Rev. GERALD MOLLOY, D.D., D. Sc. (Dublin: M. H. Gill and Son.)

These notes are a reprint of a series of articles which appeared last autumn in the columns of the *Freeman's Journal*. The first two chapters of the book are devoted to a general discussion of the various systems of electrical distribution, the principles underlying them, and the districts most suitable for their application. In Chapter III. we have a detailed description of the A.T. and B T. systems. In Chapter IV. the author "discusses the question of cost, and come to the conclusion that the evidence at present available goes to show that for domestic use the electric light can be supplied with profit at about 30 per cent. above the price of gas, for an equal amount of illumination; and that for street lighting, a public body working without profit can furnish a far more brilliant illumination than we now have at a price very little in excess of what we are now paying for gas. The last two chapters are respectively devoted to the Heisler and continuous-current transformer systems. This little volume may be read with advantage by anyone desirous of obtaining an elementary knowledge of the pros and cons of the many systems of electric lighting now competing for public favour."

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ON LIGHTNING-GUARDS FOR TELEGRAPHIC PURPOSES, AND ON THE PROTECTION OF CABLES FROM LIGHTNING,

With Observations on the Effect of Conducting Enclosures.*

BY DR. OLIVER J. LODGE, F.R.S.

(Continued from page 40.)

I will now describe the principle of my own lightning-guard, and will then connect it to the circuit in place of Saunders', and show that it affords practically complete protection for both small and big flashes.

The principle is one very easy to understand. It is merely to take the overflow from one protector, and give it the chance of

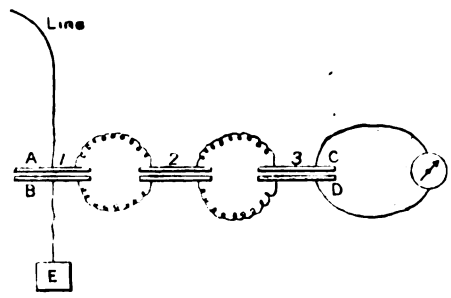

FIG. 8.

another, then to take the overflow from this and offer it another air-gap, and so on, till nothing is left; at the same time diminishing the overflow from each protector as much as possible by the use of self-induction coils, which impede the violently varying or alternating rushes by their electro-magnetic inertia.

Thus, for instance, using a series of plate protectors, we may couple them up as shown in Fig. 8.

Only a small fraction of a sudden shock will escape No. 1; say a thousandth part, since it is offered the inertia or impedance of the coils as the only alternative. A thousandth of this, again, may escape No. 2; and a thousandth of this, or a thousand-millionth of the whole, is all that is left for the galvanometer. By adding to the series, if it were necessary, it is manifest that a disturbance may be diluted down to any desired extent, with the rapidity of a geometrical progression.

I do not, indeed, propose to use plates commonly; simply because they are more bulky than necessary, not so easy to adjust, and not so open to inspection as knobs or points. Moreover, the first or exposed pair of such a series is likely to be damaged by lightning; and when damaged, it may be permanently short-circuited or otherwise inconveniently altered in a troublesome and invisible manner. I prefer that the terminals of the first air-gap hall be easy to examine, easy to remove, and cheap to replace.

The last air-gap of a series I prefer to be very finely adjustable, indeed, with screw adjustment; and all of them should be open to inspection, so as to avoid accidental contact on the one hand, or undue air space on the other. I therefore propose simple brass rods for the exposed air-gap, adjusted just far enough apart to exclude that disturbing thermo-electric or other effects caused by a spark occurring between their surfaces. All rods must be short, so that heat-expansion may not short-circuit them. The theoretically best place to tap off the useful current is from near the tips in contact, so as to tap off a minimum of impedance with a maximum, as thus, Fig. 9:—

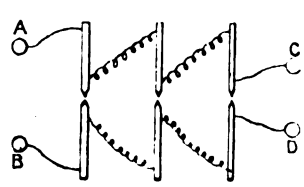

FIG. 9.—A, B, are the exposed, or line and earth, terminals; C, D, are the protected terminals. Corresponding terminals are lettered the same in all the diagrams.

Making a rough model of such an arrangement, with coils of a few yards of stout gutta-percha-covered wire, wound on cotton reels, I tested it by inserting a scrap of extremely fine wire between D and C, by holding them with wet fingers, and so on; but was unable to fuse the finest wire, or to feel any disturbance, although great flashes were going to A and B, and the early air-gaps were sparking properly. Large condensers, composed of great piles of window glass—the same condensers as I had used for obtaining very slow oscillation—and the discharge of which had a powerful deflagrating effect, were used in this experiment, as well as more moderate capacities, such as a Leyden jar battery and single jars; but still no effect at the protected terminals. This was the stage I had reached when I read my last Paper—the one on lightning conductors, &c., before this Institution.

I have now to report that Dr. Alex. Muirhead has kindly made me an actual and highly-finished instrument on this plan; designing it himself. This instrument I have here (Figs. 10 and 10A), and I have also received from him to-day this round and more compact and, I suppose, cheaper form of the same instrument (Figs. 11 and and 11A); with one-half the coils omitted, according to a plan of mine which, though not in all respects so theoretically satisfactory, may answer well enough for many purposes—as I shall mention further on.

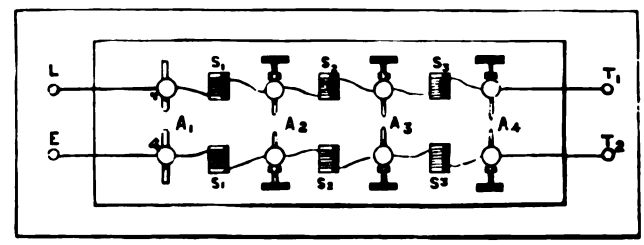

FIG. 10.

I now insert the first-mentioned protector in the path from Leyden jars to galvanometer, and I show that with all-sized flashes, from the smallest to the biggest here practicable, the galvanometer is protected; its needle does not move, neither does its safety valve sparkle. Examining it still more strictly and rigorously, I find that the insulation protection is indeed quite perfect; but a faint trace of a wave does pass round the galvanometer wire, and affects the needle slightly when in a sensitive condition. To see this clearly, one must allow the needle to recover from the disturbance due to the charging current before permitting the discharge. The galvanometer shows easily the charging current from a common frictional plate machine; in fact, the spot of light moves several inches with such a current. Connecting it up through the protector, with a small single-pair-of-plates inductive machine charging the jars and giving pretty long sparks, the usual occurrences observed are as follows:—Between each spark, while the jars are charging, the spot of light deflects considerably, gradually less as the jars get fuller, until they discharge; when, instead of a kick back, as one might expect, there is rather a leap forward, by reason of the suddenly restored strength of the now almost unopposed charging current.

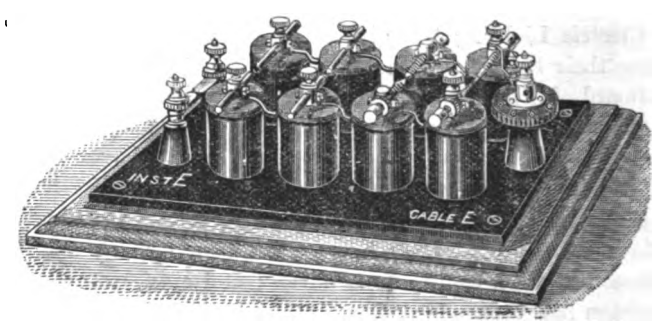

FIG. 10A.

Whenever we thus want to see the charging current, we must of course make fair metallic contact with the outsides of the jars, so as to close the circuit through the galvanometer; but, in order to further test the instrument, I make a break at one or both of its terminals, and allow flashes to strike either L or E, or both. It is not really a more severe test than the other—not quite so severe, in fact; but it looks worse, perhaps, and at any rate it is the simplest plan of keeping the charging current out of the galvanometer, and so securing that the needle shall be ready to indicate the slightest effect which the unfiltered off portion of the discharge is able to produce. But there is practically no effect to be seen.

* Paper read before the Institution of Electrical Engineers, on April 24, 1890.

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You observe that my instrument is symmetrical, *i.e.*, that there are just the same coils in its earth-connected as in its insulated portion. It may easily be supposed that this doubling of the parts is unnecessary, or even deleterious. It may be plausibly argued that coils interposed in the earth connection are bad as well as useless, and that both the terminals on that side, E and T_2 should be agglomerated together; that, in fact, a preferable pattern would be that shown in Fig. 11, where there is only one earth terminal towards which all the others point. I think, indeed, that there are many cases where this will serve sufficiently

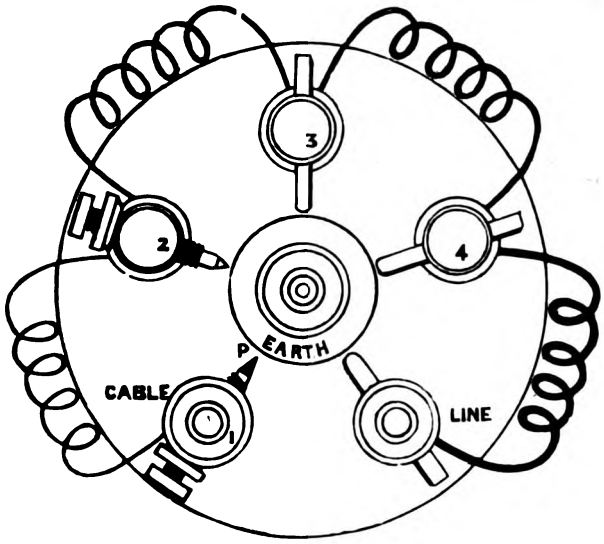

Fig. 11.

well, but I do not regard it as so theoretically sound as the other, for this reason. It proceeds on the assumption that every disturbance arrives from above and is anxious to make its way to the earth. But we have no guarantee that such shall be always the case; disturbances are as likely to reach the apparatus from below, surging up from earth to line, and in that case the coils are wanted in the earthed half of the instrument. I return to this question later.

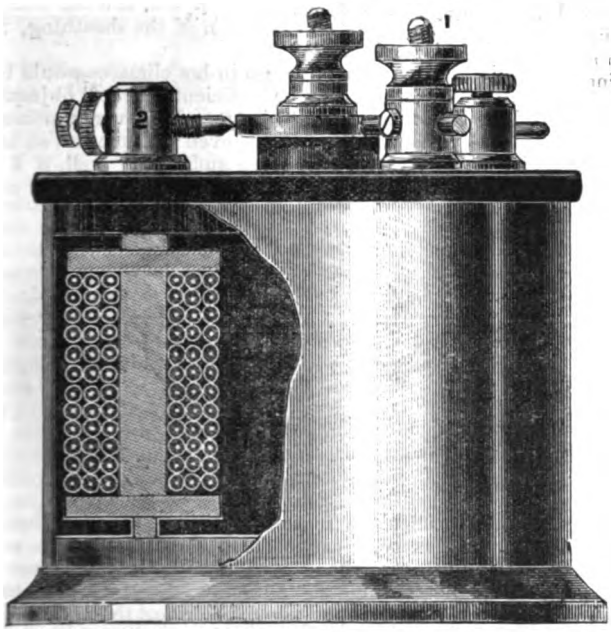

Fig. 11a.

When I speak of a disturbance travelling from earth to sky, instead of from sky to earth, I do not mean that in one case the sky is negative and in the other positive; questions about sign of charge having nothing to do with it. There is some amount of unnecessary haze abroad on this matter. Think of a sudden electrical disturbance imparted to a thin isolated copper wire; it starts at some point and flashes along the wire with precisely the speed of light, and the electric wave or pulse reaches the different portions of the wire in successive epochs of time.

Instead of a single wire, think of what must always exist, viz., a closed circuit; two pulses or waves originating at some point of this circuit flash round it both ways, at a pace usually rather less but never more than the speed of light, and meet at the antipodes of the starting point. If the circuit is unclosed, each pulse will get reflected and return, surging to and fro perhaps several times, and in such cases any point of the wire is reached by pulses travelling first one way and then the other—a phenomenon very characteristic of disruptive disturbances; but the first pulse is likely to be the strongest. It must be clear, I think, that for such alternating currents, as well as for rushes of uncertain direction, a symmetrical protector is best.

To illustrate these things, make a few more experiments with Saunders' protector, which I choose as one of the best; any other will do.

Experiment No. 8.—Connect a Saunders' protector to earth and to any line wire in the proper way, and attach a single wire to the "protected" terminal: like the wire CG. in Fig. 3. Now send a discharge between line and earth either way, and the "protected" wire will be found ready to give off sparks at every flash. It will spark to anything: to the earth, to an insulated body, even to its own earth screw B or D. Connect to it a galvanometer, or, better, a coil of wire one has no compunction in spoiling; then if the far end of the coil be attached to anything, either to the earth or to another line, or to an insulated body—even an insulated body of small size—sparks between the turns of wire will demonstrate the fact that the insulation is being broken down by the lateral waves rushing along the nominally "protected" wire, and being either reflected or absorbed according as it is connected to an insulated body or to the earth. The connection which permits least disturbance is to the screw B or D. But there must be no chance of the galvanometer being either purposely or accidentally connected to earth in some other way also, else even this partial protection has its virtue removed.

Experiment No. 9.—The "earth" in the previous experiment being the gas pipes: instead of striking the instrument by a flash direct, let a flash be imparted to the gas main at some other point—say, in another room—to typify the possibility of a lightning flash striking the earth in the neighbourhood of a telegraph station. Immediately some of the charge splashes up from the earth, and the protected wire again emits a spark; or, if it be connected to anything by a scrap of fine wire, that wire may be deflagrated. Thus we see that earth connection is not so utterly safe as might be supposed: secondary surgings may rise up out of the ground and do damage to whatever is conected to it. I believe there are more instances of such occurrences than are usually recognised. But I prefer to leave the enumeration and discrimination of instances to persons of experience.

Experiment No. 10.—But now insert in the so-called protected wire an arrangement of air-gaps and self-induction coils, after the fashion which constitutes my system of protection (Fig. 12). Then,

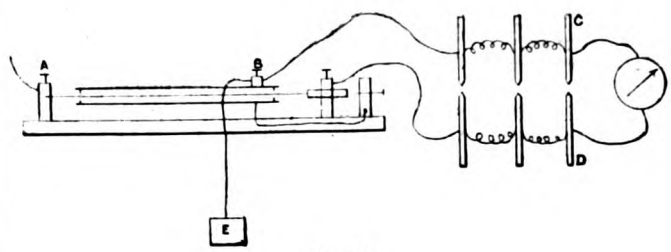

Fig. 12.

inserting a fine wire, or a coil, or a galvanometer, or any other detector, in the interval, and connecting the far end of the wire to anything as before, it will be found that although every trace of signalling current is able to affect the galvanometer, no appreciable trace of a violent disturbance is felt there; it is now securely protected whichever way the disturbance comes.

The electro-magnetic inertia possessed by the coils protects it from sudden currents in the same manner as the inertia of a penny protects it from disturbance when it is balanced on a finger with a card under it, and the card smartly flipped away. It is not, however, to be supposed that inertia alone, without successive air-gaps, can exert this protective influence. The coil of a galvanometer has plenty of the required impedance, far more than the thick wire coils on my instrument, but the only effect of that is to shunt violent disturbances through the insulation—by no means a satisfactory property. The *combination* of air-gaps or escape valves along with obstructive inertia is essential to the device. Let me here interpolate the remark that the self-induction of my coils is quite small; a very small amount of wire thus distributed suffices. Three or four yards of No. 16 wire are all I need use. I am well

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aware of the objection to introducing great self-induction in circuits where rapidity of signalling is desired.

With respect to the use of the one-sided pattern (Fig. 11), its effect will be represented in Fig. 10 if the right-hand set of coils are short-circuited out by a thick wire. In that case the galvanometer, though it is protected from disturbances arriving from the left, is exposed to those coming from the right.

This dichotomised pattern is therefore only permissible when there is a fair presumption, or complete certainty, against disturbances arriving this way. Cases of this sort will be mentioned in connection with the protection of cables.

The patterns so far drawn correspond rather to the sort suitable for a terminal station; but for an intermediate station where an "up" and "down" line wire meet, but where there is no necessary "earth," except an earth adapted to filter off lightning disturbances from the wire instead of passing them from station to

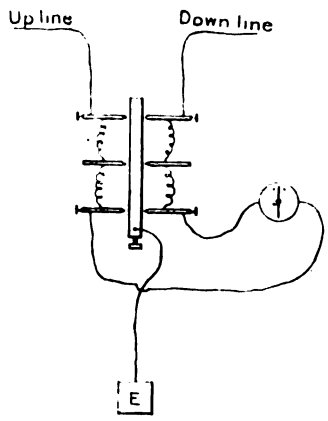

Fig. 13

station, the above pattern is suitable (Fig. 13). It explains itself; it is virtually the round pattern doubled.

Submarine Cables.

All that has been said applies by implication to the protection of cables, as much as to any other sort of covered wire out of which it is desired to keep violent rushes of potential, but about cables there are a few special things to be said which we will proceed to say now. Not only is a cable a tremendously valuable piece of property in which a slight fault costs a large sum to repair, and hence the utmost precaution ought to be taken in their case (even the instruments employed in signalling being so expensive as to deserve a thorough protection if it can be given), but the fact that cables are always coated with a stout metallic sheathing is a peculiar circumstance not found in the lines of land telegraphs, whether overhead or underground, and it is a circumstance which, I wish to point out, renders their complete protection from lightning peculiarly definite and easy.

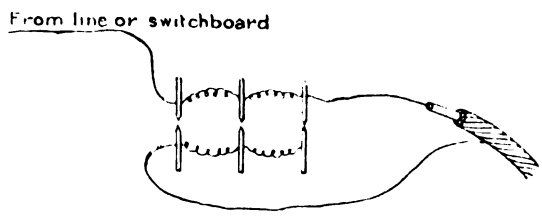

Fig. 14.

First, it is clear that risk is run wherever a cable is connected to a land line. I do not suppose this is ever done with the long ocean cables; but for short lengths, across gulfs, &c., I suppose transmission is usually immediate. Even with ocean cables I understand that the land line to the station is often led to the same switch-board as the cable instruments are connected to; and whenever there is any sort of proximity of this kind, a flash received by some distant part of the land line must be liable to spit across some of the terminals and flick off a bit of itself into the cable and its instruments.

Two lightning switches at least ought to be employed in every such station: one, a coarse one, at the place where the land line enters the building, to eliminate the grosser violence; and another, a fine one, at the mouth of the cable, to filter out the last traces of dangerous disturbance.

A proper mode of connecting one of my protectors to a cable is shown in Fig. 14. Here the outside sheath of the cable is used as sole earth, as is, I believe, customary. Another proper mode is to have a subsidiary or local earth, connection being made as in Fig. 15.

I am not prepared to support one of these in strong preference to the other. The second plan, however, is not to be adopted without the local earth. If there be no local earth, the first is the only proper plan, for it permits disturbances coming down the line to get to the outer sheath of the cable as directly as possible, the interior being protected by impedance; it also permits disturbances surging up the cable sheath, as they may when the shallow shore water is struck by a flash, to get to the line capacity directly, and not to easily enter the cable core.

But now suppose a case where no land line or connection is permitted to come within many yards of the cable station, though I suppose such a plan would be extremely inconvenient; let the cable be connected to nothing but its own instruments—where is the need of a lightning switch then?

The only danger that can occur now is when these instruments are struck direct, either from the roof or walls, or from gas pipes, or from the earth upon which they stand. A filter must therefore be arranged to protect the cable, even in this case. No fragment of cable core exposed outside its sheath can be considered safe. It would only be quite safe if it could be wholly put inside its metallic sheath and kept there.

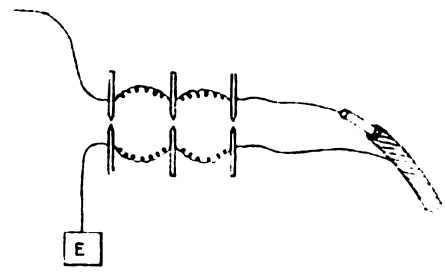

Fig. 15.

But while so carefully contemplating the protection of the cable, why not protect its instruments as well?—for a siphon recorder and an artificial cable are no cheap toys. It can be done perfectly well. Put them all inside the sheath of the cable, and they are safe. Of course the sheath of the cable must be enlarged to receive them, but that is easy enough. Use a metal house, and at the point where the cable enters it attach thoroughly its sheathing wires to the house, making a good joint all round, and the thing is done. The cable station is now an expansion of the sheathing, and everything inside it is perfectly safe.

It may be objected that a metal house in hot climates would be a nuisance. Very likely; there may be sufficient practical objections to the plan, but that is for others to judge. However, continuous sheet metal is unnecessary. Wire gauze, even with meshes so large as is used for poultry yards, may serve sufficiently well, if a few stout wires be added to make effective contact with the cable sheathing.

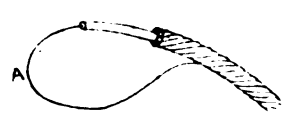

Fig. 16.

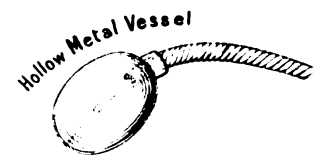

Fig. 17.

Unless practical difficulties in so casing in a cable station are greater than any I foresee, I cannot help thinking that it would be worth while, because then, even during a thunderstorm, the operators might continue signalling in undisturbed security, instead of having to suspend operations, disconnect the instruments, and short-circuit the cable to its sheath. Slow trails of disturbing current might indeed render signalling difficult or even impossible, but there would be no danger.

Reliance is commonly placed on the short-circuit of cable and sheath. If the short-circuit is very short indeed, the reliance is fairly justified; but if it be effected by a loop of any size (Fig. 16) then there is no absolute security; for a flash striking at A will bifurcate, and part of it rush into the cable. It may be said that that will not matter, because another part of it will be travelling down the outside, and that hence the G.P. between the two pulses (the internal and the external) will not be strained. But there is no guarantee that they will travel at the same rate.

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There is indeed every certainty that they will not. The outside pulse, moreover, will soon dissipate itself by leakage into sea water, leaving the internal one to work its way out through any weak place it can find. Several hundred volts is a very insignificant potential for such a pulse, but it is not customary to apply several hundred volts to a cable with equanimity.

But if instead of a mere loop we put a thimble or hollow metal vessel over the end of the cable, connecting its sheathing to the walls, and connecting its core to the interior, then no sudden splashes can enter the cable at all, they will keep to the outside and do no harm (Fig. 17).

Such a magnified thimble is the proposed metallic or wire-netted cable station; and it is one that has the advantage of never needing to be removed; one which contains instruments and operators, and protects them all alike from dangerous disturbances (Fig. 18).

It may be asked whether such a house should depend for its earth entirely on the cable sheathing, or whether a local earth should be provided.

It is not a vital point, but a local earth is to be recommended in order that even the outer sheath of the cable shall not have to carry flashes of exceptional violence, which might unduly heat it. Extra earthing the house can do no harm, and may thus occasionally do good. But do not think of sending out to any local earth a wire from the earth terminal of the recorder or any testing instrument inside. The inside of the metal house is their appropriate earth, and no other must be permitted. Again, gas pipes, water pipes, and everything else may be permitted to enter the house, but only on the strict condition that they be effectively united to it at their point of entering—not at some other point. Connecting them or anything else to the house by a mere wire is not a bit of good. The cable, the gas pipes, and every other

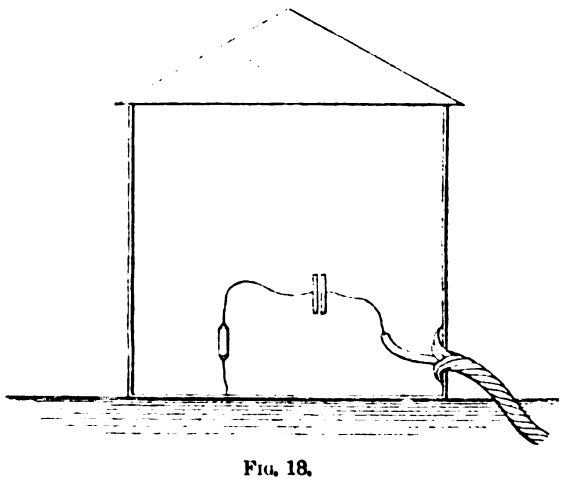

Fig. 18.

conductor which penetrate the walls of the house must be *at that place* united to those walls. I have ample experimental as well as theoretical grounds for this assertion. No insulated conductor must be allowed to protrude, unless it be enclosed in a metallic sheath connected to the walls, with the distant end of this sheath itself closed. Such an insulated conductor is, of course, the core of the cable itself; the completing closed sheathing being the distant cable station. If that be a mere wooden shanty disturbances may there enter the cable, and not only do it damage but derange the signalling power of your instruments at this end also; all your fine protection being no good if not imitated at the far end of the cable.

Since no insulated conductor must on this plan be allowed to penetrate the walls, it is manifest that no land line can be permitted to enter a cable station. The land signalling station must be a separate chamber. It need not be a distinct building; it may be under the same roof, but it must be wire-fenced off from the cable compartment, and the messages must be put through non-electrically.

Whether such a separation is too inconvenient to be contemplated I leave to those with more practical knowledge to say. I am only pointing out what is necessary for absolute protection. Of course, a reasonable amount of protection can be obtained under less stringent conditions, and I am by no means laying down the law as to what ought to be done in practice; all I say is, that unless all this is done the protection will not be absolute. Practical men are far the best judges of questions relating to temporising and expediency. For instance, windows and doors are necessary in a cable station, and although they may be fenced over with wire netting, it is not to be supposed that in all conditions of practice they will never be left open, or that there will never be a break or a serious imperfection in the continuity of the metallic sheathing to the house; and in face of the liability to such accidents, it is not to be supposed that proper lightning-guards can be dispensed with. They will, however, then become the last citadel of security, and not, as at present, the outer line of defence.

It is customary, I believe, to land the ends of cables in a cable hut on the beach, so as to be able to get testing instruments as close as possible to the real thing, undisturbed by insignificant shore leads. There is not the slightest difficulty or danger introduced by this practice, provided the hut or an enclosure inside it is made of iron, and both cable and shore lead are well connected to its walls by their outer sheathing as they enter it. Testing instruments and all inside the enclosure are then perfectly safe, except from disturbances conducted in through the central core of the lead; and this can only happen when there is some great defect at the cable station. It is this lead from hut to station which now represents the cable, and all the care described as proper to be taken of the cable must of course be taken of it.

The cable hut need not be itself of iron; if it contains an iron box, as shown in Fig. 19, all requirements will be satisfied, and such a plan may perhaps be convenient; the lid can be removed for occasional testing without appreciable risk. In case a trace of disturbance should by chance get into the lead, a lightning switch may, for a final appeal, be included in the box.

I said above that there were cases when the dichotomised pattern of Fig. 11 was sufficient. This is one of them. There is not the slightest objection to a single terminal here, connected with the inside of the box, because nothing violent can splash up into it.

The box may advantageously have some rude local earth of its own, merely in case its hut should happen to receive a direct flash of lightning.

Experiment No. 11.—To demonstrate the protecting action of cages I put a parrot cage over a thin wire reflecting galvanometer standing on a copper plate through which a lead-sheathed cable passes, the lead being attached to the copper where it passes through the hole by a number of soldered wires. If this junction is defective the experiment is liable to fail—*i.e.*, the protection will not be thorough. The cage also should be well connected with the copper plate. The terminals of the galvanometer are connected,

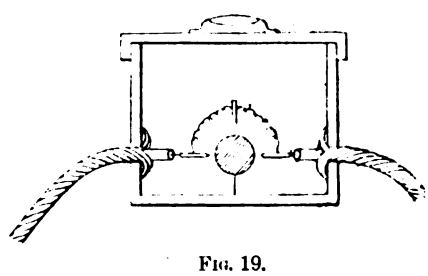

Fig. 19.

one to the inside of the cage at any point whatever, the other to the core of the cable. The distant end of the cable may be similarly treated, or for simplicity its core may be directly connected to its sheathing, and a tight-fitting metal thimble or hat put over it. Before doing this, however, I apply something representing a signalling E.M.F. to the distant end, to show the sensitiveness of the caged galvanometer—*e.g.*, touching the core and its sheath simultaneously with a pair of wet fingers immediately drives the spot of light off the scale.

All being properly arranged, flashes are sent from a jar to any point of the cable—to its far end, or to the cage of the galvanometer, &c.; some other point of the cable or cage being earthed. Not a wink does the needle show, at any rate to cursory inspection; and if a safety valve be supplied, no matter with how microscopic a spark gap, it cannot be made to overflow.

But, all the time these flashes are going on, an operator in the distant cage may be sending voltaic currents along the cable and signalling to the sensitive galvanometer inside the cage without any disturbance from the violent rushes outside.

It is not to be supposed that such cable houses afford any protection against earth currents, or any other steady or slowly varying effects. These will produce their full effect quite careless of the fact of metallic enclosure. Nothing but a *perfectly* conducting screen can entirely protect against them, and that is not a likely invention. Atmospheric disturbances also, and even discharges, *in so far as they are slow* or leave subsiding effects behind them, will be felt by the galvanometer; but then, although inconvenient to a reader of signals, slow disturbances are not dangerous. It is the violent and sudden rushes that are dangerous, and these are wholly excluded, occurring only in the outer metallic sheath. To exclude steady currents of too great strength a short length of very fine wire must be included in the circuit.

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Experiment No. 13.—To emphasise the fact that the galvanometer is not in the smallest degree protected from steady currents, except in so far as the resistance of core and bobbin bears a large ratio to the resistance of sheath and cage, according to rudimentary laws of divided circuits, I take the terminals of a single storage cell and touch them to two points of the outer sheath of the cable an inch apart like A B (Fig. 20). Instantly the spot of light is flung off the scale. Apply the terminals to points one-eighth of an inch apart only, the needle is still strongly disturbed; and, indeed, it is only by very careful feeling about and adjusting within the hundredth of an inch on the same sectional circumference of the cell-sheath that a neutral position for the second terminal can be found, and the galvanometer ceases to tap off any fraction of the current. Diagrammatically the arrangement is this:—

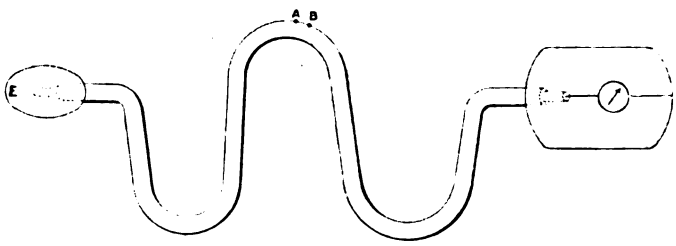

Fig. 20.

With the terminals at A B the galvanometer plainly receives a minute branch current, unless A B are coincident.

The simplest way to realise the matter is to recoganise that when a current is passing in the sheath from A to B all the left-hand portion of the cable is at A potential, and all the right-hand portion is at B potential; hence, of course, there is a tendency to leak along any available path between the two portions; and the core is such a path.

But Leyden-jar flashes may be sent, not merely to points close together like A and B, but to points as far apart as you please, like E and F, and the galvanometer shall show nothing.

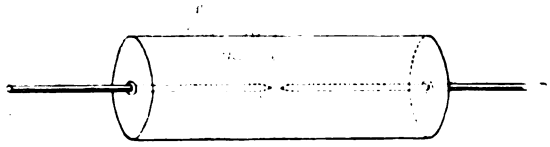

Fig. 21.

But now arises a very interesting question. The protection thus illustrated, is it theoretically perfect, or only perfect enough for all practical purposes? Does a metal cage protect a galvanometer absolutely from these sudden disturbances?

Put it in another way. Everybody knows Faraday's cage, or metal-lined room, into which he went with electroscopes, birds, frogs, and other instruments, arranged that the outside should receive violent flashes, and detected nothing inside. Suppose he had added to his stock a galvanometer, connecting its terminals to two points of the walls, would he have got anything then? It naturally occurs to ask, why did he not try it? What would he have expected the result to be? Did he perhaps not try it because he felt already sure of the result? If so, the feeling of certainty was premature. Whether his guess might happen to turn out right or no, he certainly had not all the facts before him on which to base an opinion.

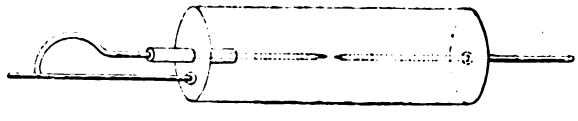

Fig. 22.

Let us go into the question. First of all, Mr. Chattock and I obtained the following result a year or two ago, viz.: that between two wires wholly inside a wire-gauze house not a trace of spark can be obtained, whatever flashes pass along the outside. The only way we got sparks inside a metal enclosure was by allowing one of the wires to protrude a little through a hole in the walls without touching the sides of the hole.

Thus, for instance, Fig. 21 gives no sparks inside, but Fig. 22 may give some very small ones.

But this last is hardly a fair device; it is equivalent to turning a portion of the enclosure inside out; the protruding wire should be a part of the interior surface. Inside a thorough and fair metal enclosure sparks cannot be got between its walls.

Recently Hertz tried what is practically the same experiment, his object being to demonstrate that rapidly varying currents traverse only the outside of a conductor (*Phil. Mag.*, August, 1889). He took a sort of mouse mill of wires (Fig. 23), and, inserting it in a place where sparks would naturally occur between the axial wires, he found it not possible to obtain any until many ribs of the mouse mill had been removed so as to leave a great gap for the penetration of electro-magnetic waves, or unless he coated the glass tube portion of his enclosure with only a film of silver so thin as to become incipiently transparent to such waves—*i.e.*, transparent to light. All this shows clearly why a cage protects a cable; no sparks are possible inside, and therefore its insulation cannot get damaged.

But what about a galvanometer or telegraph instrument?—*i.e.*, what about the conduction test? Insulation is safe enough, but will the signalling be interfered with during the continuance of a storm?

Well, if we try the experiment by putting a galvanometer inside a good conducting vessel and attaching its terminals to the walls—a small patch of gauze being, of course, provided for the ray of light to get in and out—nothing will be seen when ordinary flashes are given to the cage; and that must certainly have been the result of the experiment if it had been tried in Faraday's time with the galvanometers of that day.

But a galvanometer is in this arrangement so severely handicapped by short-circuiting that it is perhaps unfair. So modify it by using an elongated form of enclosure and attaching a low-resistance galvanometer to points of it a good distance apart. The metallic sheathing of a cable is such an elongated enclosure; hence modify the simple cage experiment thus:—

Experiment No. 14.—Instead of the thin-wire galvanometer, which we find easy to protect, encage a thick-wire galvanometer and join it up to the lead-covered cable as already described, with good connection between cage and sheath. Sheathe also the distant end, and connect up as in Fig. 20. Now send flashes to E or to F, or to both; or spark to E, and let F be earthed, or *vice versâ*. The galvanometer gives a slight kick at every flash. Its safety valve shows nothing, but a feeble pulse does pass round its wire.

Fig. 23.

When I first got this effect the cage employed was a common parrot cage; but, since its wire junctions could not be depended on, I had one made of fine copper gauze, soldered to a disc of copper at top and to a flat ring at bottom, suitable for clamping down to a copper plate. The same disturbance being still found when it was used, a solid sheet-copper water-tight hat was next made and soldered down to the plate, the gauze cage being placed over it as a supplemental and outer covering. Still the residual effect remained, apparently unaltered in strength.

The protection of a galvanometer from these sudden discharges is, therefore, not theoretically complete. No amount of covering-in can absolutely eliminate all disturbance. No matter how sudden a pulse may be, so long as there is an integral passage of electricity in one direction along a conductor, the central portions of that conductor will convey some trace of it. The integral passage of electricity along the axial wire is, in fact, that determined simply by its relative conductivity as compared with its surrounding sheath, irrespective of more complicated considerations. But whereas in the outermost layer of the sheath there are violent surgings, the current-strength being very great and alternating, nothing of the sort occurs in the central portions; the violence is all damped out, and there remains nothing there but a quiet and sluggish flow. The rush in the outer layer of a conductor induces currents in the layer next below, these again in the layer below that, and so on; a sort of diffusion of currents occurring towards the axis, like the diffusion of heat in a body to whose surface heat, or an alternation of heat and cold, has been suddenly applied. Such diffusion is accompanied by a flattening out of the waves, a decay of all their suddenness, so that the axial disturbance is a mere peaceful flow, analogous to that given by a voltaic cell, not having a trace of jump left in it. The very smallest breach of continuity stops it altogether: it is impossible to get a spark in the axial wire; but if this wire be a completed conductor it takes its share of integral current along with the rest. Not simultaneously, however; this diffusion inwards occupies time, but the delay has no particular effect to call for notice here.

Another way of putting the matter is to use the mechanical analogue of slipping wheel-work as representative of a conductor;

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then, if the outer layer of wheels be spun to and fro violently and left with a certain residual spin, to represent the impact of electro-magnetic waves from the dielectric on the metal, that residual spin will penetrate to all parts of the geared mechanism, except where there is absolutely perfect slip—*i.e.*, except into space bounded by a perfect conductor.

To suppose that the axial part of a conductor (whether solid all through or hollow with a wire along its centre makes no difference in principle) takes no part in conveying a momentary transfer of electricity, is to make the same error as is published so uniquely and interestingly by Sir William Thomson in the March, 1890, *Phil. Mag.*, wherein he corrects his original idea that the ordinary resistance of a ballistic galvanometer wire would not be the right resistance to introduce into its formula, because the outer layer of the wire conducts most of the current; and shows that, examining the matter still more completely, every part of the wire is ultimately effective, and equally effective as regards integral flow. All the rush does go by the outside at first, and all the *violence* is there expended anyhow, but every part of the section does its full share of conduction ultimately.

It is worth entering thus fully into the matter, because these are things about which it is easy to get bothered if one does not happen to get hold of them right way up. And this matter of protection by cages is one on which there has long been some uncertainty or hesitation.

Now that I see clearly how they act, their behaviour seems natural enough, and what one ought to have expected—what I think Maxwell (doubtless others also) would have expected; certainly it all comes out clearly enough on his principles. But a little time ago the matter was by no means so clear in my mind, and I rather gather that several others felt a similar sort of temporary uncertainty.

One more way of putting the result may be permitted. It is not given as an experiment, because I have not tried it. Take a sheet of metal or gauze, tap it along a certain line with a galvanometer on one side and with a spark gap on the other, arrange to send flashes along the same line, and then fold the sheet into a cylinder either upward or downward, so as to enclose at pleasure the galvanometer or the spark gap, but not both (see Fig. 24).

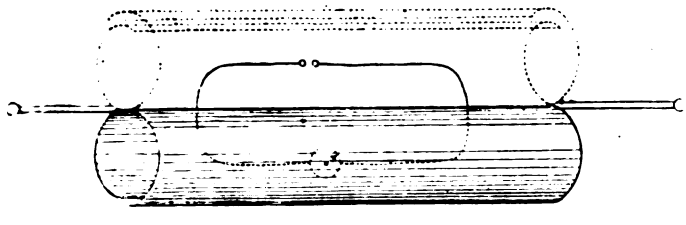

Fig. 24.

The indications of the galvanometer will be wholly unaffected by the way the sheet is folded, or whether it be left flat, provided always the insulation of its wire is and remains perfect. But to the air gap the folding of the sheet makes all the difference; when enclosed it will be quiescent, when exposed it may sparkle.

DATA AND PLOTS OF VARIOUS INCANDESCENT LAMPS, TOGETHER WITH AN IMPROVED METHOD OF TESTING.*

BY W. L. PUFFER.

Since the appearance of the report of the Franklin Institute on incandescent lamps in 1885 there have been no published measurements either of the efficiency or of the distribution of light of the best-known lamps now in the market. The Franklin Institute data, therefore, although very valuable as showing the state of the art in 1885, are of no especial value for use with the lamps now manufactured. The following data and curves have been calculated and plotted from the observations made by Messrs. Walter G. Whitmore and Edwin R. Pearson, class of 1887, Massachusetts Institute of Technology, who took as the subject of their graduating thesis "A Study of the Efficiency of Incandescent Lamps." The method used is substantially like that of the Franklin Institute, but I have changed and improved the method of plotting so that the five plots tell the distribution of light, shape of filament, and its position in regard to photometer, &c. This method of testing lamps is in regular use in the laboratory, with very satisfactory results.

* Abstracted from the *Electrical Engineer*, of New York.

The standard of light used is a Methven screen, which has been standardised by comparison with many standard candles at different times and by different observers, and also with a Harcourt standard burner. The photometer is a modified Bunsen, 100in. long, graduated into inches and tenths by a dividing engine, and having also a scale of "ratio" which, when multiplied by the candle-power of the standard, give candle-powers directly. Both the standard burner and the lamp under test are thoroughly screened, so that little if any diffused light reaches the eye of the observer. A key near the observer's hand and a lamp overhead furnish light when needed for reading.

The lamp-holder is quite different from that used by the Franklin Institute, and will hold any of the lamps now in the market without danger of straining. The socket, with lamp under test, is screwed on the end of a brass rod, which is free to slide or rotate in a sleeve fixed in the centre of and perpendicular to a disc of brass. Set screws are provided for clamping the rod in the sleeve. The disc is arranged on the bottom of a U-shaped strap in such a position that it can be turned, while the rod always remains parallel to the sides of the U and in the same plane. The disc has notches every five degrees, and the strap carries a locking pawl, which also serves as an index. The U-shaped strap is pivoted near the top in a frame, so as to have rotation about a horizontal axis; it also has a notched disc, and the frame a pawl and index. One arm of the U is longer than the other, and carries a movable counterweight. This apparatus is set with the horizontal axis perpendicular to the line of the photometer and on a level with the centre of the greased disc, the vertical circle being adjusted to read 0deg. when the lamp stands vertical with the socket underneath; then the horizontal disc is placed at 0deg., and the rod carrying the lamp moved till the plane of the shanks is perpendicular to the line of the photometer and the horizontal axis cuts the filament midway of its length. This position of the lamp is called the "standard position," and the photometer reading for this position the "standard reading." By means of the horizontal circle any desired degree of longitude can be instantly turned towards the photometer, and, by the vertical circle, any degree of latitude.

Electrical measurements were made by a set of carefully calibrated Thomson's current and potential galvanometers, placed in a room free from magnetic disturbances, where the value of the earth's component had been determined. As the current taken by the potential galvanometer bears a very sensible ratio to that in the lamp, the instrument is always kept in circuit, and a correction is made for the current passing through it. An adjustable resistance in the lamp circuit enabled the observer to keep the potential at the right amount. The potential galvanometer used was adjusted for Rayleigh volts.

When the lamp had been placed in the "standard position" and the potential adjusted, candle-power readings were taken at 65 different positions; the value used for each position being the mean of three or four settings of the disc, according to the method used by the observer. The standard direction, to which all others are referred, is a line perpendicular to the plane of the shanks of the filament, and lying in the equator of the lamp. By equator is understood the line cut upon the glass globe of the lamp, when upright, by a horizontal plane half-way up the filament. Zero point, or 0deg., is the starting point for measuring the angular rotation of the lamp, and is at the intersection of the standard direction and the equator.

Horizontal distribution is measured by candle-power readings at each 30deg. around the equator, beginning and ending with 0deg., or the "standard direction." Of these 13 candle-power readings, the first and last should, of course, check.

Mean horizontal candle-power is the mean of the first 12 of these readings, the check reading being omitted.

Vertical distribution is measured on each of four complete meridians, *i.e.*, those of 0deg., 45deg., 90deg., and 135deg. on the equator. On each of these four circles candle-power readings are taken at every 30deg. (of latitude), beginning and ending with 0deg., thus giving 13 readings, the first and last of which should check.

Standard reading is the mean of all readings in the direction of the zero point ("standard position"). It is an arbitrary position selected for convenience. By it and the "reduction factors" the candle-power (spherical or horizontal) may be determined under any given potential or current, at any subsequent time, by one reading. Great care should be taken in placing a lamp in this position, because in some lamps a very slight error would make a very considerable difference in the candle-power, and, of course, in the "factors." When a number of tests are to be made on any one type of lamp, it is preferable to select a point on the horizontal circle in that part of the curve where the rate of change of candle-power is very small, and so avoid error due to hasty or imperfect setting of the lamp for the standard reading.

Mean spherical candle-power is computed from 38 readings, selected from those described, with the aim of obtaining the average

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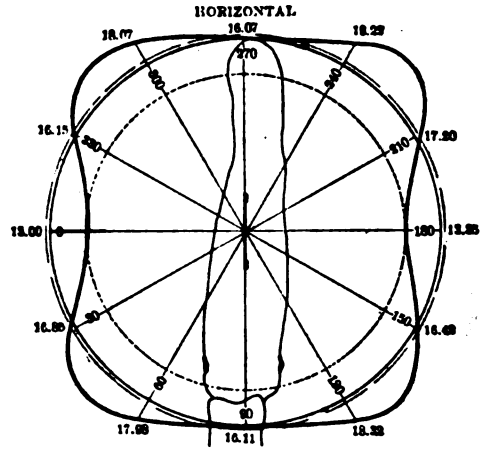
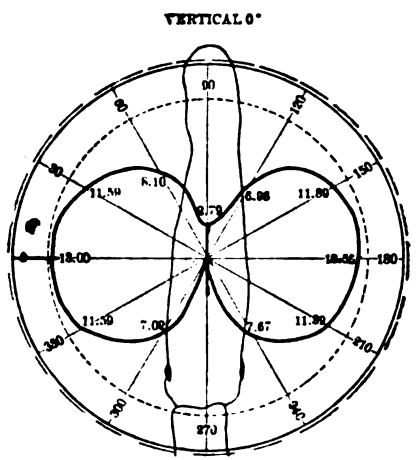
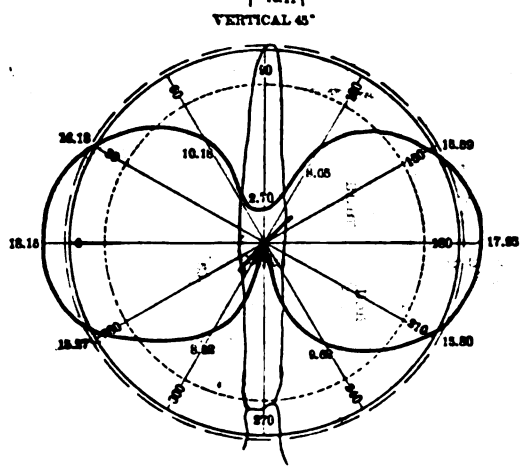
Lamp.—Edison, 101 volt. 16 c p
Mean standard reading = 13.00
Mean spherical c. p. = 13.25.
Spherical reduction factor = 1.02.
Mean horizontal c. p. = 16.46.
Horizontal reduction factor = 1.27.
Mean sph. c. p. ÷ mean hor. c. p. = 0.805
Volts = 100.9.
Amperes = 0.789.
Watts = 79.58.
Watts per mean sph. c. p. = 6.00.
Watts per mean hor. c. p. = 4.84.
Rated c. p. = full circle.
Mean sph. c. p. = dotted circle.
Mean hor. c. p. = dashed circle.
Section of filament = ■
Scale, 10 c. p. per inch.

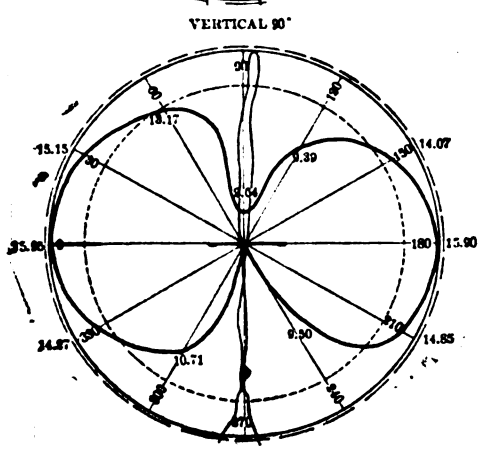
W. L. P.

Full circle reduced from 3.2" to 2.5" in engraving.









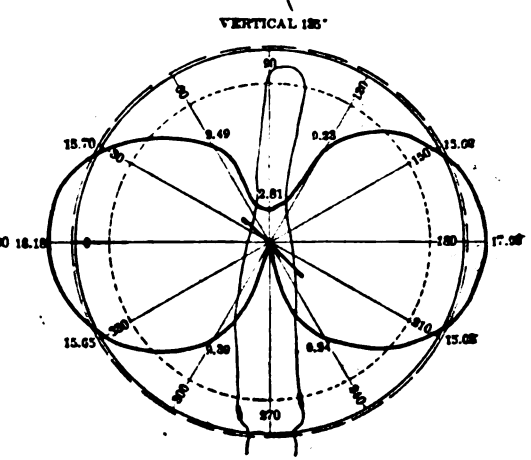
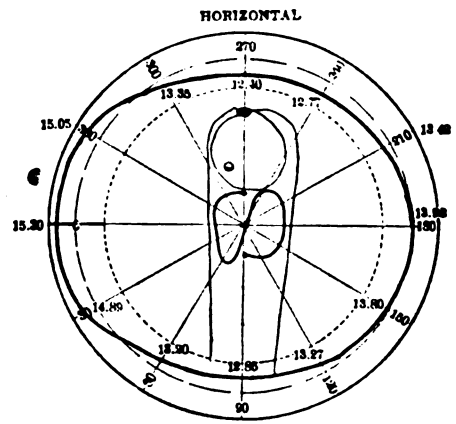


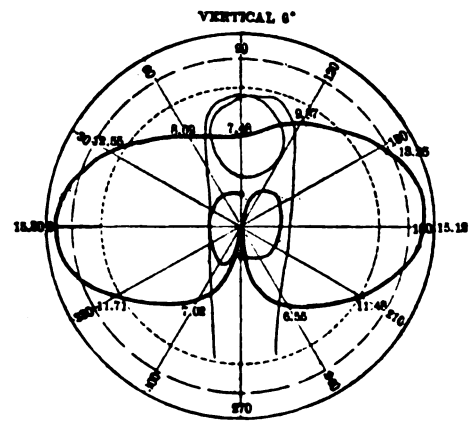
PLATE I.

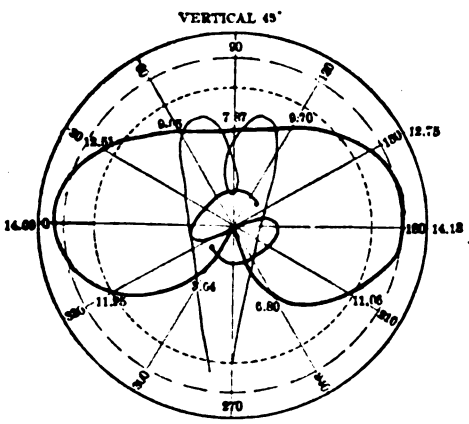
Lamp.—Swan, 92 volt. 16 c. p.
Mean standard reading = 15.30.
Mean spherical c. p. = 11.49.
Spherical reduction factor = 0.751.
Mean horizontal c. p. = 14.00.
Horizontal reduction factor = 0.915.
Mean sph. c. p. ÷ mean hor. c. p. = 0.821.
Volts = 91.98.
Amperes = 0.594.
Watts = 54.64.
Watts per mean sph. c. p. = 4.76.
Watts per mean hor. c. p. = 3.90.
Rated c. p. = full circle.
Mean sph. c. p. = dotted circle.
Mean hor. c. p. = dashed circle.
Section of filament = ●
Scale 10 c. p. per inch.

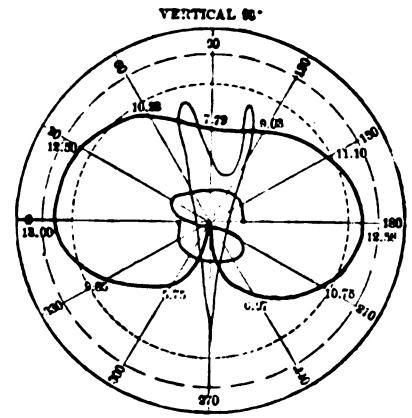
W. L. P.

Full circle reduced from 3.2" to 2.5" in engraving.









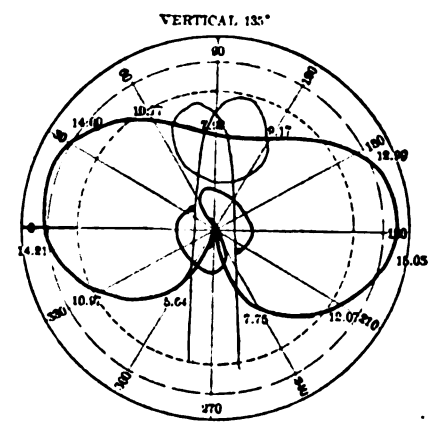


PLATE II.

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RESULTS CALCULATED BY WILLIAM L. PUFFER FROM THE OBSERVATIONS OF MESSRS. WHITMORE AND PEARSON, CLASS OF 1887.

Lamp.—1887.	Voltage.	C.P.	Mean standard reading.	Mean spherical C.P.	Spherical reduction factor.	Mean horizontal C.P.	Horizontal reduction factor.	Spherical ÷ horizontal.	Volts.	Amperes.	Watts.	Watts per spherical C.P.	Watts per horizontal C.P.	Lamps per electrical H.P.	Mean spher. cand. per electrical H.P.	Mean hor. can. per electrical H.P.
Weston	70	16	16·63	14·25	0·857	15·13	0·909	0·942	69·96	1·021	71·43	5·01	4·72	10·4	149	153
Weston	110	16	8·97	10·96	1·222	13·37	1·491	0·820	110·1	0·530	58·36	5·32	4·36	12·8	140	171
Thomson-Houston	52·6	20	21·00	16·32	0·801	20·69	0·985	0·813	52·61	1·250	65·76	3·91	3·18	11·3	191	235
Thomson-Houston	75	16	16·00	13·31	0·832	16·18	1·011	0·823	74·93	0·705	52·87	3·97	3·27	14·1	188	228
Thomson-Houston	110	16	13·00	10·50	0·808	12·86	0·990	0·816	100 1	0·472	51·95	4·95	4·04	14·4	151	185
Edison	101	10	10·50	8·25	0·785	10·38	0·987	0·795	101·9	0·512	51·65	6·26	4·98	14·4	119	150
Edison	101	16	13·00	13·25	1·021	16·46	1·27	0·805	100·9	0·789	79·53	6·00	4·81	9·4	124	154
Edison	101	32	26·53	28·59	1·078	34·21	1·290	0·836	100·9	1·295	130·7	4·57	3·82	5·7	163	195
Swan	36	8	8·09	6·61	0·817	7·76	0·959	0·852	35·96	0·786	28·26	4·27	3·64	26·4	175	205
Swan	38	16	13·10	10·57	0·807	12·25	0·937	0·863	38·05	1·300	49·65	4·70	4·05	15·0	179	203
Swan	46	8	7·39	5·89	0·797	6·70	0·907	0·879	45·93	0·534	24·56	4·17	3·67	30·4	210	244
Swan	46	16	15·54	14·38	0·925	16·73	1·077	0·859	45·99	1·113	51·18	3·55	3·06	14·6	141	177
Swan	92	10	8·88	7·17	0·807	9·03	1·027	0·794	91·98	0·413	38·00	5·30	4·21	19·6	157	191
Swan	92	16	15·30	11·49	0·751	14·00	0·915	0·821	91·98	0·594	54·64	4·76	3·90	13·7	185	217
Swan	92	32	33·57	27·74	0·826	32·48	0·968	0·854	91·98	1·215	111·8	4·03	3·44	6·7	159	184

intensity of light in all directions. These readings are as follows:—

Mean of 4 north pole readings (longitude 0°, 45°, 90°, 135°) counts							1
Longitude	0°,	Latitude	60°,	120°,	240°,	300°,	giving 4
„	90°,	„	60°,	120°,	240°,	300°,	„ 4
„	0°,	„	30°,	150°,	210°,	330°,	„ 4
„	45°,	„	30°,	150°,	210°,	330°,	„ 4
„	90°,	„	30°,	150°,	210°,	330°,	„ 4
„	135°,	„	30°,	150°,	210°,	330°,	„ 4
Equator, 12 readings (or mean horizontal × 12) counts							12
South pole reading assumed zero and counts							1
Total							38

The values for these positions are selected, added, and divided by 38.

Horizontal reduction factor is the mean horizontal candle-power divided by the standard reading.

Spherical reduction factor is the mean spherical candle-power divided by the standard reading.

The mean spherical candle-power divided by the mean horizontal candle-power gives a very useful factor, which is not so much affected as the two above by a slight error in setting the lamp in the exact standard position. Obviously the product of the standard reading taken at any time and the reduction factors will give the horizontal or spherical candle-power without any other measurements.

The method of plotting the results of a test on a lamp is thought to be an improvement on the Franklin Institute method, and is designed to show at a glance:—

1. The distribution of light in five great circles. 2. The relative position of the lamp filament to the photometer at the zero of each circle. 3. The appearance of the filament as seen from the photometer disc at the zero of each circle. 4. The rated candle-power. 5. The mean spherical candle-power. 6. The mean horizontal candle-power. 7. A table of data.

TABLE *showing Position of Lamps when arranged in order of their efficiency in watts per spherical candle-power, and other data.*

Lamp.	Voltage.	Rated c.p.	Watts per spherical c.p.	Watts per horizontal c.p.	Spherical c.p. Rated c.p. per cent.	Horizontal c.p. Rated c.p. per cent.
Swan	46	16	3·56	3·05	89·9	105
Thomson-Houston	52·6	20	3·91	3·18	84·0	103
„ „	75	16	3·97	3·27	83·2	101
Swan	92	32	4·03	3·44	86·7	102
„	46	8	4·17	3·64	73·6	86·3
„	36	8	4·27	3·67	82·6	97
Edison	101	32	4·37	3·82	89·4	107
Swan	38	16	4·70	4·05	66·1	76·6
„	92	16	4·76	3·9	71·8	87·7
Thomson-Houston	110	16	4·95	4·04	65·6	80·4
Weston	70	16	5·01	4·72	89·1	94·6
Swan	92	10	5·30	4·21	71·7	90·3
Weston	110	16	5·32	4·36	68·5	83·8
Edison	101	16	6·00	4·81	82·9	103
„	101	10	6·26	4·98	82·5	104

All of these lamps were bought in the winter of 1886-87, of supply companies in Boston, out of stock, and presumably could not in any way be picked lamps. The Edison lamps had the copper-plated shanks, and are now (1889) known as the "old lamp." The Weston 110-volt lamp is not now in the market, and I believe was on sale for only a short time after these were bought, an improved lamp taking its place. I do not know whether the 70-volt Weston lamp of the kind tested is in the market or not. The Thomson-Houston and Swan lamps appear similar to those now in the market, and are, as far as I know, the same.

A study of these tables and plots (see Plates I. and II.) will make it very evident that there is no commonly accepted value of a candle-power, or, if there is, that different makers vary widely in their attempt to produce it.

THE AMERICAN TELEGRAPHERS' FAST-SENDING TOURNAMENT.*

BY PATRICK B. DELANY.

As there are forty or fifty thousand people talking about the young Yankee Pollock, who brought his bundle of thews and nerves down from a Connecticut town, and coolly stretched the record out of each at the fast-sending tournament, we might as well see what this cheeky manipulator really did. In his first trial he poured out a stream of dots and dashes to the tune of 51½ words per minute; and then, like Mark Twain's coyote, when his speed was questioned let out another link in his backbone and shoved the record up to 52 words per minute, making 260 words in the five minutes given to each contestant. It is claimed, and with some reason, that the work was not plain and perfect. I know that the sending of Messrs. Gibson, Ayres, Waugh, and Bradt was vastly superior as to quality, and of such a character as not to fly off the poles in turning sharp angles; but still, I think, the "Yankee Blade" made all the signals, and that the lack of clearness so noticeable was, in a great measure, due to the great speed and his lightness of touch.

It has been the custom heretofore for commercial operators to turn up their noses at the railway operator, and Pollock seems to have made up his mind to avenge the slights and indignities so long and lavishly heaped upon his train-guiding brethren. Admitting that his juggling of the signals had many of the characteristics of a railway accident, still, every time I caught the thread of his discourse I found him putting it all in honestly. I couldn't follow him all through. Even the air-brakes seemed powerless to hold him. He was a sort of runaway train going down grade, and if the time-keeper hadn't opened the switch on him, there is no telling where he would have fetched up. Now, if Pollock, Jr., made all the signals, I claim that, regardless of classicality, he has performed a wonderful feat, and I am strongly of the opinion that so great a number of impulses, of any kind, have never before been made in the same time.

I have been experimenting a little since the tournament, with a view of ascertaining whether, if Mr. Pollock had made all dots, he could have crowded any more into his record than the number of mixed dots and dashes credited to him; and I have come to the conclusion that the almost infinite number of changes involved in the transmission of the English language by dots and dashes is restful to the operator, and that if he were compelled to make the letter "p" or figure "6," consisting of all dots, at top speed, for five minutes, his muscles would be practically paralysed. It is easily tried. Others may find it different.

Since Fast Sending Tournaments promise to increase in interest from year to year, I have no doubt that certain improvements will

* From the *Electrical Engineer*, New York.

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be made in their arrangement which will contribute to the speed of the operators and to the certainty of decisions by the judges. Nothing was plainer than the consideration and fairness of all connected with the tournament just closed; but when writing climbs up into the fifties, it becomes very misty, and faults are difficult of detection. I have many times tested the limit of sound reading by using a punched strip and machine transmission. Sixty to sixty-five words per minute can be followed, if the matter be familiar to the ear, or with the manuscript before the listener, but this must be from a strip careful'y punched. I think, therefore, that a Wheatstone recorder should be used for receiving the writing of each contestant. This instrument, properly adjusted, will record over 500 words per minute, so that there need be no fear of anything being missed. I would suggest also that a condenser be used to prevent sparking at the key points, especially if a considerable number of sounders are to be used in the circuit. It occurred to me and some others that one first-rate sounder placed in the centre of the hall would be more satisfactory than a number scattered about, some well adjusted, others not. With a single sounder there would be a unanimity of opinion regarding the quality of the work.

An analysis of the real meaning of Pollock's wild flight is interesting. It shows that the 260 words transmitted in five minutes call for 1,223 letters and 11 punctuations, or say, 1,234 letters in all. To make these letters 2,834 impulses were required. This puts over nine impulses into each second, and as each impulse calls for a down and up motion of the key, the hand and fingers of the "Railway Guide," from Hartford, had to make nearly 19 movements per second for 300 consecutive seconds. If anyone thinks he carries more agility than this about his person, fame awaits him—if he is not mistaken.

I doubt very much if there be any one living able to write out words at this speed. Forty-five words per minute will claim any man's undivided attention, so that until the penmen can put more steam into their fingers, Pollock's gait would be useless, even if it could be maintained—which it could not. It is fair to assume, however, that a man who can do 52 words per minute in any shape, might send grandly at the rate of 45 words per minute. If the elder Catlin's pace and beautiful style of transmission were general throughout the country and there were receivers to put it down, the earning capacity of the telegraphs would be just about doubled. Here is something for managerial meditation. There is money in it. When a boy like young Catlin, not yet old enough to vote, can double the work of an ordinary circuit, he becomes a duplex. He should be encouraged.

To my mind the great speed and general excellence of the work of the young women was the most remarkable feature of the contest. It was a revelation to one who has not been very close to the sounder for some years. I considered 32 or 33 words per minute the winning speed in their class, but how the glory of old times faded when 43 and a fraction were poured out with ease and grace without untying a bonnet string. I think the quality of the young women's work averaged higher than that of the men.

I find that there are 636 dashes in the 260 words sent by Pollock, or an average of about one dash to two letters. Five letters to a word is the usual way of reckoning. If Pollock had to furnish five letters to a word, his score would be 246¼ words. But 4⅗ to 4⅞ is nearer the average. This may be proven by counting the letters and words in a few columns of the editorial page of the New York *Sun* any day.

In the first 50 words of the 260 there are 600 Morse characters; in the second 50 words, 566; in the third 50 words, 531; in the fourth 50 words, 532; in the fifth 50 words, 503, and in the 10 words which distinguished Pollock, there are 102 characters. There is a difference of 97 characters between the first 50 words and the fifth. This is equal to five words. As young Catlin sent 251 words and one letter, or 2,738 characters, he is just 96 characters behind Mr. Pollock.

There were 13 women and 34 men in the contest. Taking the highest figures of each contestant, they foot up a total of 9,955 words transmitted, or an average of nearly 42½ words per minute for each of the 47 operators. The women averaged 39⅔ words per minute, the men 43½. All praise to the ladies. Great is Pollock.

THE RAILWAY RATES INQUIRY.

This inquiry was continued on Wednesday at the offices of the Board in Whitehall, before Lord Balfour of Burleigh, and Mr. Courtenay Boyle, C.B.

Mr. STUART, on behalf of the Postmaster-General, objected to the inclusion of "telegraph poles" in the exceptional class with a minimum of two waggons and one ton per waggon for every waggon used. The railway companies contended that the Post Office was sufficiently protected by the provision that the charge must be reasonable; but that was simply begging the question, because the companies made what charge they liked, there was no means of testing its reasonableness.

Mr. TWELVETREES, of the Great Northern Railway, defended the classification on the ground that the Clearing House arrangement had been adhered to, and that the class contained other articles as well as telegraph poles, such as boilers and ships' masts, which required exceptional treatment in transit. It was necessary in many instances to use more than one waggon in carrying them. For this reason they had been put in the exceptional class.

LORD BALFOUR OF BURLEIGH said the question was not whether there should be a universal application of the classification, but whether it was the correct classification for telegraph poles. How long had the classification been in force?

Mr. TWELVETREES stated that telegraph poles had been in the exceptional class for many years, with a minimum charge of one ton per waggon.

Mr. COURTENAY BOYLE thought the argument for putting timber, such as telegraph poles, in the exceptional class was not very strong.

Mr. WILKINSON, of the Great Western Railway, remarked that he was at Reading on Saturday with Sir Douglas Galton, when he saw a consignment of telegraph poles which were so long that it required five waggons to take them.

Mr. STUART said that would be a very exceptional case. The Post Office did not object to a minimum consignment of two tons being charged. The railway companies defended their classification of copper wire on the ground that it was six or eight times as valuable as iron wire. That, however, was not the fact. Copper wire was practically undamageable, and no claim had ever been made by the Post Office for injury in transit. With regard to "telegraph wire, coated with gutta percha," He, on behalf of the Post Office, claimed that this article should be included in a lower classification. It was undamageable and easily handled, as might be seen from the manner in which it was drawn through iron tubes in the streets of London. This article was much less damageable than many of the articles already in Class 3, into which the Post Office claimed that telegraph wire coated with gutta percha should go. He further said he thought that in the case of telegraph insulators the railway companies had met all the objections of the Post Office by allowing them to go into Class 1.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 9, 1890.

The Edison Company and the Zipernowsky Alternate-Current Patents.—An interesting feature of the alternating-current squabble that has made sport for the lawyers during the last few years is a suit brought by Ganz and Co., of Budapest, against the Edison Electric Light Company. In 1886 the Edison Company obtained the American right to the Zipernowsky alternating system, paying for the same some $5,000, and agreeing, so Ganz and Co. allege, to introduce it into the United States. As is very well known, they have not done so; and now Ganz and Co. file a complaint before the United States Circuit Court, saying that the rights to the system were obtained by misrepresentation on the part of the Edison agents; that whereas an agreement was made to introduce it into the United States, so far from being introduced, it has been assiduously suppressed; therefore the complainants pray to be released from the agreement, and ask suitable damages. This is all very interesting from a legal point of view, but its exact significance in view of the present stage of the alternating current discussions, is not easy to find.

The Physiological Effects of Electrical Currents.—*Apropos* of the English experiments on the physiological effect of electrical currents, the experiments of Dr. Edward Tatum, recently published, may prove of some interest. Dr. Tatum has spent much time and care in studying the effect of both continuous and alternating currents, and the results which are reached are of importance. His experiments were tried upon dogs, and were aimed to discover the actual mechanism in producing death. This has been generally ascribed to violent action upon the nerves, especially the cerebral centres controlling the pneumo gastric system. Dr. Tatum shows very clearly that the action of the current is something more than this, and in fact makes it evident that a large part of the action is not on the brain but on the heart itself. He found it possible to pass a strong current through the head of a dog without a fatal result, while a current equally intense applied to the region of the heart produced almost immediate death. Besides this, he separated the pneumo-gastric

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system from direct action on the heart by experiments on dogs that had been previously dosed with atropine or curare. In addition, in one set of experiments he completely eliminated the connection of the pneumo-gastric system by cutting the vagus nerves. Under these circumstances, the current still produced instantaneous death with the same readiness as before. With etherised dogs, he found, however, that there was somewhat greater tolerance for electric currents, particularly alternating currents, than in the case of dogs not under the influence of anæsthetics. The general tendency of his experiments is to show that the death from electrical current is due to something besides nervous shock. At the same time he effectively sets aside the sensational statements that have been made concerning alternating currents. He made no attempt to investigate the difference of mode of action which might exist between continuous and alternating currents; but his experiments are conclusive in showing that although the alternating currents certainly kill more readily than continuous, they are far less fatal than some recent experiments have led us to suppose.

CORRESPONDENCE.

HIGHER TECHNICAL EDUCATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your concluding remarks in the last issue referring to Prof. Percy F. Frankland's Paper recently read before the Society of Arts are quite to the point, and deserve to be repeated over and over again. It is very well for English professors to visit Continental "Technical High Schools," and on returning comment upon their "aim and scope," upon the elaborate teaching staff, the amount of money granted by the Governments, and the handsome buildings erected for this purpose. These numerous institutions certainly turn out thousands of what one may call over-educated youths; but let the question be asked: What becomes of all these men whose training has cost the State enormous sums of money? What is the result of this vast sacrifice of money, time, and brains? Has Prof. Frankland and the other enthusiasts taken the trouble of ascertaining the number of men who have neither the chance nor the ability of utilising their store of acquired knowledge?

If he has inquired into this he will have found that at least 70 per cent. of these over-educated youths do not follow up the theoretical training by practical applications. The vast majority take positions as clerks in the Civil Service, become soldiers in the standing army (as distinct from those who serve the compulsory term); many turn to be mercantile clerks, bookkeepers, draughtsmen, shorthand writers, railway station-masters, and perhaps tramway conductors. The few gifted ones, if they work hard after they leave the schools, unlearn much they did learn, and learn that which they ought to know in order to be useful; these few gifted ones, together with a few who have influential friends, turn out bright professional men, and are held up all the world over as samples of higher technical education. But these very men would have made their mark in any country, even in England and in America, where this super-technical-State training does not exist, provided that they had a moderately decent education to start with. Great Britain and the United States, the two countries which do not possess those higher technical institutions, after the models of Switzerland, Germany, and Austria, can boast not merely of the greatest number of first-rate engineers, but also of a preponderance of men of genius in the technical professions.

I could point out, on the Continent, some technical high schools which had 15 or 20 years ago an average of a thousand students, and which have to-day no more than 150 or 200, although in the meantime these institutions have been improved, and cost now as much, or even more, to maintain than formerly. The fact of the matter is that there are too many of these high schools; the Governments have educated more scholars than were wanted, and the supply exceeds the demand. At the same time the attendance in the technical middle schools (Realschulen and Gewerbeschulen) has steadily increased, and much of the best talent comes from these. These lower technical schools prepare boys efficiently for practical apprenticeships.

Manufacturers prefer young men who passed creditably through these lower technical and trade schools. It is perhaps natural that the student who spent several years in the "high school" (where he acquired much knowledge with little understanding) should be proud of his achievements, and assume a certain amount of conceit. But he soon finds out that he is utterly unable to earn a living, and he has in most cases to work for no salary for a year or more, after which time for another year or two he is bound to accept a miserable pittance which any skilled mechanic would be ashamed to receive. If you ask the manufacturer why this is so he will tell you that the "high school" man gets all or more than he deserves, and that he prefers the practical intelligent mechanic. Of course, there are a few instances when much theory is appreciated, as in laboratories; but these instances are rare.

It would be a great pity if such a system were initiated in this country. The City and Guilds of London and kindred institutions are on the right track; and it would be better to extend these, and uphold the sound apprenticeship system, than follow the advice of Professor Frankland and other advocates of unsound educational doctrines.—Yours, &c.,

London, May 19, 1890. A. RECKENZAUN.

THE LANE FOX DISTRIBUTION PATENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A paragraph in your issue of the 16th inst. seems to imply that Mr. Lane Fox's patent for distribution, No. 3988** of 1878, only shadowed forth the bare outline of a system the essential details of which were laboriously worked out by others. That Mr. Lane Fox did something more than this is evidently the opinion of more than one eminent authority. Sir William Thomson writes in 1886, "The system of distribution . . . is a useful and largely used invention at the present day." Prof. Perry writes in the same year, "The method described by Mr. Lane Fox is what is in use at the present time." Clearly, then, these gentlemen are of opinion that Mr. Lane Fox did something more than "shadow forth a scheme."

Passing to the latter part of the paragraph; you complain that royalties are to be exacted by Mr. Lane Fox from "those who have laboriously worked out the essential details." Let us examine how the matter really stands. Mr. Lane Fox worked out the principles; others have elaborated details. Mr. Lane Fox has, up to the present, charged nothing for the use of his patents; he now proposes charging a small royalty. The gentlemen who have "laboriously worked out the details" have charged royalties for the use of their improvements. That they had a perfect right to claim the fruit of their inventions will, I think, be generally admitted; but, granting their right; on what principle can the same privilege be denied to Mr. Lane Fox?—Yours, &c.,

C. A. STEPHENSON, Managing Director,
Lane Fox Electrical Co., Ltd.

2, Princes Mansions, Victoria Street, S.W.,
May 19, 1890.

[In the paragraph in question we did not imply that the Lane Fox Electrical Company (Limited) had no *right* to exact royalties in the event of the Patent No. 3,988 of 1878 being held to be valid, but we *did* imply that under the circumstances the electrical industry was to be congratulated upon the fact that the patent shortly expired.—ED. *E.*]

THE EFFICIENCY OF GLOW LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have a few remarks to make on the subject of your leading article "The Efficiency of Glow Lamps" (*The Electrician*, May 9th).

If instead of the words "efficiency of glow lamps" one could impress upon one's mind, what is practically an equivalent expression, *i.e.*, temperature of incandescence of glow lamps, then this subject would be more clear and intelligible. The plan in general use, at least among lamp-makers, of expressing the

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rate of efficiency of a glow lamp in watts per candle-power, is all that is desirable and is practically correct enough.

A short time ago (*The Electrician*, February 28th, p. 432) I pointed out in your columns the necessity of fixing upon some recognised standard rate of efficiency (3½ watts per candle-power), and I then said this was equivalent to fixing on a standard temperature of incandescence. I would like to hear of any important objections there may be to this suggestion, for to me it seems the only practically possible one. I have also remarked in another letter (*The Electrician*, March 7th, p. 458) (which you remarked was not very clear to you), that if there were a fixed standard rate of efficiency, *i.e.* (temperature), then comparative data as to the life of lamps at any other rate of efficiency could be obtained by reference backwards or forwards to the standard rate. I find, that for practical use, the life of a lamp may be taken as about inversely proportional to the sixth power of its rate of efficiency (temperature), as compared with its life at any other rate of efficiency (temperature), which in my practice I take at 3½ watts per candle-power.

The greatest difficulty in the intelligent adoption of such an expression as the rate of efficiency of a lamp in watts per candle-power lies in the great uncertainty and variation that now exists amongst the trade as to what is a candle power. Until there be a recognised and fixed standard (such as, say, the English standard one candle-power on a Harcourt-Pentane lamp), all such expressions as above are useless. I find these variations especially in my practice here on the Continent, where lamps from various makers are in use; and I have to use reduction tables to find what are the actual volts, amperes, candle-power, watts per candle-power, &c., of the other manufacturers as compared with my own legal volt and ohm and the English standard one candle-power. In one factory the English one candle-power Harcourt-Pentane standard is used; in another, the Carcel burner; in another, the German standard sperm candle; in another, the Hefner-Altneck amyl-acetate lamp, with a flame at 40mm. high; and so on. Hence can be seen what complications, uncertainties, and variations are likely to arise in the intermixing of such variously-tested lamps. It is this great variety in the units of light that will alone account for the large variations in the watts per candle-power that Mr. Puffer has observed.

The most important object for a lamp manufacturer to keep in view is to have well-recognised exact standards, such as the legal ohm, the legal volt, and Harcourt's Pentane lamp, and then to turn out lamps all running at the same rate of efficiency in watts per candle-power (*i.e.*, temperature). With a reliable wattmeter this becomes an easy matter, and the naked eye is in itself a wonderfully exact judge of the comparative efficiencies of lamps. For instance, having two lamps of the same dimensions, surface, &c., then a trained eye can observe a difference of one volt in a 100-volt lamp. Reading from my notes I see that this would be judging within ¼ of a watt per candle-power (0·25 watt per candle-power), so that having fixed standards a trained eye could always prevent variations in the rate of efficiency inside of 0·25 watt per candle-power, and this would mean that lamps would be sent out having a definitely fixed temperature, although they might vary among themselves as to their actual candle-power. When, on the other hand, the eyes come to observe candle-power at different rates of efficiency (temperature), then the variations likely to arise are enormous and very misleading.

It is easy to see that variations in candle-power among the lamps comprised in any particular installation are not of such paramount importance, but that very great exactness in their rate of efficiency (temperature) is necessary, and that this is, *cæteris paribus*, the best means of ensuring similarity in and length of duration.

I must take objection to your remarks "that the manufacturer of glow lamps is far from equalling the dynamo maker in being able to turn out a large number of articles which are all practically identical." If you had said, "the manufacturers of glow lamps are far from equalling the dynamo makers, &c.," then I would heartily agree with you, and I have above pointed out the causes tending to this present state of things; but I, as an individual manufacturer, find no difficulty whatever in turning out any number of lamps which are all practically identical and well within the percentage of accuracy a dynamo-maker would be satisfied with. It is a daily practice to turn out lamps for a particular order, having a maximum variation of less than ½ in their candle-power, ¼ in their watts per candle-power, and 1 per cent. in their voltage; and this order can be repeated at any future date with the same accuracy.—Yours, &c.,

C. J. ROBERTSON, A.I.E.E.

Middelburg, Holland, May 13, 1890.

ELECTRICAL TRAMWAY SYSTEMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read Mr. Allsop's letter in your last issue, and have obtained copies of the specifications to which he refers. We observe that Mr. Allsop finds it difficult to see any new points in our system; and we are not surprised at this, if, as would appear from his letter, and indeed from his specification, Mr. Allsop attaches no importance to mechanical details, which he thinks may be entrusted to any mechanic. In our opinion, and we would venture to say in the opinion of engineers at large, a successful invention is not so much dependent on a happy idea as on the careful consideration and working out of the many details essential to enable such an idea to be put into a practical working form. It is to these essential details that we have devoted our attention; and, notwithstanding Mr. Allsop's opinion to the contrary, we still think that our system is very far from being identical with that which he proposes.

It is unnecessary to enter into a lengthy controversy in your columns in regard to the differences between Mr. Allsop's system and our own; and so far as your readers are concerned their interest will naturally be confined to an examination of the practical merits of the system, and the relative merits of our respective claims can have no bearing on this side of the subject.—Yours, &c.,

J. EDWARD WALLER.
E. MANVILLE.

Princes Mansions, 68, Victoria-street, Westminster,
London, S.W., May 20, 1890.

LIGHTNING PROTECTOR DISCUSSION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am a little surprised to learn from your editorial remarks this week that Prof. Hughes' observations in the recent discussion at the Institute of Electrical Engineers conveyed the impression that the principle of my lightning guard had already been unconsciously applied. I did not remember hearing this maintained; but when my Paper is published I imagine it will be clear that it is certainly not the case.—Yours, &c.,

OLIVER J. LODGE.

LEGAL INTELLIGENCE.

Shangan v. Metropolitan Electric Supply Company.

This was a motion which came on before Mr. Justice North on Friday last for an interim injunction to restrain the defendant company from continuing to create a nuisance by noise in conducting the operations of building and constructing electric lighting works. The plaintiff was a lodging house-keeper at 11, Manchester-street, Manchester-square. The defendants were constructing an establishment for electric lighting in the rear of the plaintiff's premises. There was evidence on the part of the plaintiff to show that there was an intolerable nuisance, and that he was likely to lose his lodgers and have his business affected. The defendants attempted to show that any noise made by their workmen was so trivial that it could not affect any one except a nervous person.

Mr. Justice NORTH said that persons living in a populous district must submit to a certain amount of inconvenience from the acts of their neighbours. He did not see any reason for interfering with what the defendants were doing in the daytime. He was satisfied, however, that what had been done during the two hours between 6 and 8 in the morning was more than a neighbour should reasonably be called on to endure. He therefore granted an injunction limited to that period of time.

In re International Cable Company (Limited).

On Saturday last Mr. Justice STIRLING delivered judgment in this case (see *The Electrician*, May 9th, p. 15). After going minutely and at very considerable length into the facts and evidence applicable to the case,

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he came to the conclusion that he ought not to hold that the concession had lapsed, and that no renewal of it could be obtained. There was some evidence, he said, that the concession might be extended, and that, so soon as the Halifax-Azores section of the cable was laid, the capital for constructing the Lisbon-Azores section would be obtainable. Since 1889 the attention of the directors had been mainly turned to the Halifax and Bermuda cable, which was in course of being laid, and it was possible that the existence of this cable might favourably influence the Portuguese Government. In the face of these considerations, his Lordship could not come to the conclusion that the negotiations had come to an end, and that the petitioner was entitled to an immediate order; and, as the Company desired delay, he should order the petition to stand over until the third petition day in July next.

Reece v. Latimer Clark, Muirhead, and Co.

In the Westminster County Court, on Monday, his Honour Judge Bayley had before him the case of Reece *v.* Latimer Clark, Muirhead, and Co., which was an action to recover damages for injuries sustained by the plaintiff through the alleged defective condition of a drilling machine.

On January 16th of this year the plaintiff was cleaning out the base of the machine prior to using it, when, without any warning whatever the drill came rapidly down, and pierced his hand, inflicting very severe injuries. Several fellow-workmen who were, at the time of the accident, in the employ of the defendant firm, were now called by the plaintiff, and were unanimously of opinion that the machine in question was in a dangerously defective state; but although that was so, they never thought it worth while to make any complaint, as they did not think it their duty to do so.

For the defence, Mr. JAMES PULLEN was called, and said he was the defendants' foreman. Up to the time of the accident he never heard a single complaint made about the machine, although it was constantly in use. It had been at work for some five years, and was as good now as when new. Like all other machines it required a little care and attention, and then it was all right.

Mr. JOHN FARQUHARSON was called, and said he was an electrical engineer at Sheerness Dockyard, and was well acquainted with all kinds of machines. He had examined the machine in question since the accident and had found it in every respect to be in a thoroughly workable condition. The working of the machine was governed by two screws, with which it was fitted and had they been judiciously made use of, he did not believe the accident would have happened.

In giving judgment, his Honour said that after hearing the evidence for the defence, he was quite satisfied that the machine was not defective, and that if properly used it was perfectly safe; therefore the verdict must be for the defendants.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

More Warnings.—We had occasion last week to caution our readers against a person who is imposing upon members of the electrical trades by securing goods on fictitious orders. This week we are asked to warn our readers against a foreigner representing himself to be in possession of a valuable primary battery invention, but in need of a little ready money to make up a sample. This individual pretends to be a Doctor of Physics of Vienna, and speaks but little English. He is described as young, tall, with black hair well combed down over the forehead, and with a well-developed "port-wine" mark on one cheek.

———We are ourselves also aware of another case in which a Pole is the inventor of a "new" arc lamp, and only wants a small amount of capital to enable him to bring it out. As this gentleman's "invention" is a clear infringement of an existing British patent, we warn our readers against his specious overtures.

Electric Light Cable for Sale.—In our advertisement columns will be found particulars as to 1,570 feet of electric light cable for sale, offers for which are to be sent to "The Exmouth Committee," Metropolitan Asylums Board, Norfolk House, Norfolk Street, W.C., before Saturday, the 31st inst.

Electrical Block Signal Appliances for Sale.—The Lancashire and Yorkshire Railway Company notify through our advertisement columns that they have a quantity of these appliances for disposal. Particulars will be furnished on application to Mr. J. A. F. Aspinall, Chief Mechanical Engineer of the Company, Horwich, near Bolton.

The Fire at Messrs. Robey's.—Messrs. Robey and Co. write us that none of their workmen will be out of employment, nor will any stoppage of business be caused by the fire which occurred at their works on Wednesday last.

Personal.—Mr. W. Moore, engaged in the electrical shop at Devonport Dockyard, has been appointed to proceed to Malta to take charge of the electrical fitting shop there.

Mr. Gladstone's Visit to Norwich.—On the occasion of Mr. Gladstone's visit to Norwich on Saturday last, the large Agricultural Hall was lit by electricity by Messrs. Laurence, Pari*, and Scott, under the superintendence of Mr. W. B. Sisling.

Mr. F. N. Newton.—Mr. Newton notifies us that, owing to the growing requirements of his business, he has been compelled to take larger premises, under the style and title of the Newton Electrical Engineering Works, Taunton, where he has removed from Barton Grange.

Mr. H. A. Henderson.—Mr. Henderson notifies us that he has devised a new method of fitting up small houses with electric bells. The prices quoted in the circular before us are very reasonable.

White's Patent Divided Wire Ceiling Rose and Pulley Attachment.—This is a ceiling rose especially designed to avoid any possible chance of the wires getting short-circuited inside the cover. The base and cover are made entirely of porcelain. A conical pillar stands up from the base, and is part of the base itself,

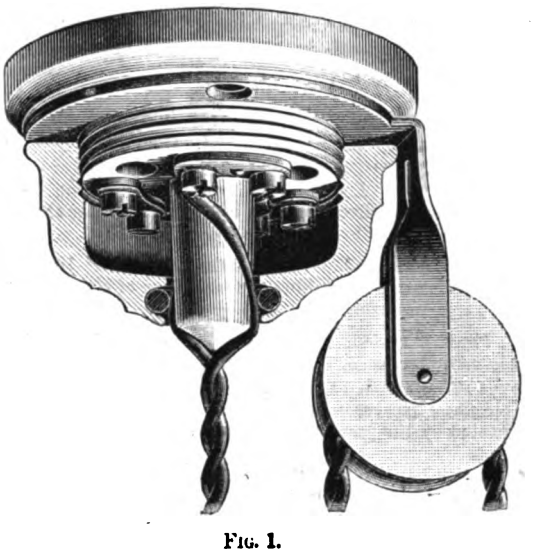

Fig. 1.

and is also made of porcelain; on opposite sides of this pillar are two spiral grooves cut in the porcelain, and running from the base

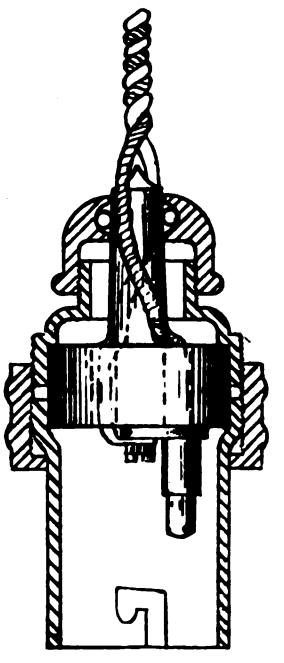

Fig. 2.

to the top of the pillar; in these grooves the branch wires leading off to the lamp are laid, and are held in place by means of a rubber ring, which fits in the hollow left for it in the cover, as will be seen by Fig. 1. The same device of a conical pillar and rubber ring is also applied to suspension holders for the same purpose as in the ceiling rose as shown in Fig. 2. The special advantages claimed by the makers are that by

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this means the wires are kept quite separate until after they have left the ceiling rose or holder; that there is absolutely no weight on the terminals; and that no dust whatever can get inside, as the rubber ring grips the wire tightly, and so takes all the weight and keeps out the dust. The pulley attachment shown in Fig. 1 is a cheap means of attaching a pulley to a ceiling rose; the pulley holder itself being made of a brass stamping, and bent up as shown in the illustration. The attachments are made in several sizes by Messrs. Poole and White, of Bread-street, Cheapside, E.C.

MESSRS. APPLETON, BURBEY, AND WILLIAMSON.—This firm notify that they have purchased the manufacturing business of Mr. F. Geere Howard, and have transferred the plant to their works at Hatton-garden, E.C.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

April 9, 1890.

5,400. R. SCHORCH. London. Improvements in dynamo-electric machines.

5,409. S. CAPPILLERI, K. KURMAYER, J. GOLDBERG, and R. LATZKO. London. Improvements in electrical arc lamps.

5,423. J. WENSTRÖM. London. Improvements relating to the transformation and distribution of energy by alternate electric currents.

April 10, 1890.

5,474. HENRY LYON and H. J. LESLIE. London. Improvements in regulating and controlling the resistance of electric currents.

April 11, 1890.

5,518. C. PRICE. London. Improvements in or relating to electric incandescence lamps (F. H. Hadfield, South Africa).

5,540. F. H. W. HIGGINS. London. Improvements in apparatus in which electrical measures are obtained by the aid of a wire or filament heated by the passage of a current.

April 12, 1890.

5,558. R. D. SMILLIE. Glasgow. An automatic switch for use in telephone exchanges.

5,562. W. EMMOTT and J. H. RIDER. Halifax. Improvements in dynamo-electric machines.

April 14, 1890.

5,640. C. WATSON. Lambeth. Improvements in electric safety fuses.

5,645. JOHN B. ODELL. London. Improvements in electric railway apparatus.

April 15, 1890.

5,678. J. KALB. London. Improvements in electric-tension regulators or apparatus for automatically controlling or regulating electric currents.

5,716. E. MANVILLE and W. L. MADGEN. London. Improvements in the method of and means for producing low-tension alternating electric currents, and applying the same to sundry purposes.

5,728. H. H. LAKE. London. Improvements in apparatus for regulating the speed of dynamo-electric and other machines (Theodore Marshall Foote, United States).

April 16, 1890.

5,748. ANDREW JAMIESON. Glasgow. Improvements in and connected with testing galvanometers.

5,750. R. E. B. CROMPTON. London. Improvements in armatures for dynamo-electric machines and electric motors (partly communicated by Waldemar Fritsche, Germany).

5,764. W. P. THOMPSON. Liverpool. Improved system of electrical intercommunication, and apparatus applicable for use therewith (A. W. Berne and B. W. Taylor, United States).

5,782. A. HIORTH. London. An electric lamp for water-closets.

5,784. H. MARLEY. London. Improvements in machinery or apparatus for winding, carding, or folding ribbons, trimmings, lace, and the like.

April 17, 1890.

5,836. J. RADCLIFFE. Nottingham. Improvements in apparatus for automatically controlling and regulating dynamo-electric machines and motors.

April 18, 1890.

5,910. A. J. JARMAN. London. Improved method of and means for insulating electrical conductors, especially applicable to high-tension currents.

5,916. C. R. BONNÉ. London. Improved electric alarm or battery bell (Actien Gesellschaft, Mix and Genest, Germany).

5,923. C. E. SLEEMAN. London. An improved electric servo-motor.

5,926. S. PITT. London. Machine for covering electrical conductors and cables with lead (J. B. Atherton, United States).

SPECIFICATIONS PUBLISHED.

1889.

1,037. BOWLES. Telephones. (Price 6d.)

3,455. LAKE (Ewing). Electric secondary batteries, &c. (Price 8d.)

3,840. CURRIE. Dynamo electric generators. (Price 8d.)

4,484. MORDEY. Electric currents. (Price 8d.)

6,520. THOMPSON, GÜNTHER and another. Electrical motors. (Price 6d.)

7,883. CUTTRISS. Electro-motors. (Price 6d.)

8,692. KINGSBURY (Western Electric Company). Telephonic switches, &c. (Price 8d.)

9,096. JACKSON and SINCLAIR. Telephonic switch-boards. (Price 8d.)

9,241. SWINTON. Electric meters. (Price 11d.)

9,713. LORRAIN (La Société d'Exploitation des Cables Electriques, Système Borthound, Bord et Cie.) Electric conductors. Price 6d.

9,917. NICHOLSON. Electrical switches. Price 6d.

9,945. HANSON. Arc lamps. (Price 8d.)

10,801. PIEPER. Electric lamps. (Price 8d.)

10,933. VON DOLIVO-DABROWOLSKY and Allgemeine Electricitats Gesellschaft. Electric motor. (Price 8d.)

19,529. HOLT. Dynamos. (Price 6d.)

1890.

3,419. VAN DEPOELE. Producing, &c., electric currents. (Price 11d.)

3,787. LIBBEY. Electric railways. (Price 8d.)

Third Editions.—1880.

3,576. HOPKINSON. Distributing, &c., electricity. (Price 8d.)

3,880. JENSEN (Edison). Distribution of electricity. (Price 8d.)

Sixth Edition.—1878.

3,988. LANE-FOX. Electric lighting. (Price 8d.)

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
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PHOSPHOR BRONZE
VULCAN PHOSPHOR DURO METAL
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BEARINGS, BUSHES,
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ELECTRICAL MACHINERY.
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COMPANIES' MEETINGS.

The Panulcillo Copper Company (Limited).

At the twenty-seventh ordinary general meeting of this Company, held at Winchester House, E.C., on Tuesday last, the CHAIRMAN (Sir John Pender, K.C.M.G.), in moving the adoption of the report and accounts, referred to the anxious period they had recently gone through. Since then there had been considerable changes, and at the present moment the Company stood in a position to take a calmer and more correct view of copper than they have been able to take at any time for a considerable period. At the last general meeting they were in the midst of the crisis produced by the collapse of the copper syndicate, and in addressing the shareholders then he said that "there could be no question that the very large and sudden fall in copper prices had placed them in very great and serious difficulty, as some time must elapse before costs in Chili could be adjusted to the low values here, and that in the meantime it had been necessary to stop smelting." It was this unfortunate state of things which led to the heavy loss in the first six months of the year now under review, In the second half the ill-effects still continued, but they were so far mitigated that after August the Company ceased to lose money, and were able to record some profits. The gain, however, in September and October only amounted to £416. In November the profit was £963, and in December it reached £1,422. These December results showed that a satisfactory proportion had been established between Chili and Europe, and that all that was required was a sufficient supply of outside ores to mix with the valuable flux afforded by the Panulcillo sulphurets. It was the want of these outside ores which had crippled their operations, for they would observe from the mining report that the position of their own mines was very hopeful, the supply in the past six months having been 161,000 quintals, against 146,000 quintals in the corresponding period of 1888, while the reserves at the close of 1889 were estimated as 863,000 quintals against 732,000 quintals in 1888, showing an increase of nearly 20 per cent. With the hopeful reports on their mines, and with the price of copper in Chili advanced by the last cable advices to $22 per quintal, the only point that troubled the Directors was a full supply of carbonate ores; for without such a full supply they could not make large profits; but with it he saw no reason why they might not look for a repetition of the prosperity of 1880-83, when, having realised sufficient to wipe out the previous heavy loss of capital, they made profits amounting to £121,000. These profits were made when the Company was subject to debenture interest, and when the average price in Chili was about $19, against $22 by last advices. The aim, and he might say the necessity, of the present day in all manufacturers is to combine in one undertaking all the processes of manufacture, and by amalgamations, or otherwise, to work on the largest scale, thereby reducing the incidence of general charges, and securing all the profits each trade can give, at the same time that it allows of the employment of the most scientific processes and management, which might otherwise be found too costly. An opinion he recently gave was that the depression in copper was exaggerated, and that with an expanding consumption, and no reserves of old copper, there would be no difficulty in establishing the value of Chili bar copper at about £50 per ton. The price now was considerably above this figure, with the prospect of some further advance. He could not do better than refer them to an article on copper, which appeared in *The Statist* of 19th ult. These views are supported by some very interesting remarks from the American correspondent in last Saturday's *Statist*. In conclusion he ventured to express the hope and belief that they were on the point of leaving all their difficulties behind them. In acknowledging a vote of thanks, the Chairman said the new market which was opening in electric lighting would undoubtedly make a great demand upon copper stocks—in fact, he knew from personal experience that there was an enormous future before the electric light, which could not be established without copper. These were facts which warranted the shareholders anticipating a growing market for the Company's products.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this Company for the week ended May 16th amounted to £3,765.

COMMERCIAL CABLE COMPANY.—It is announced on behalf of this Company that at a Board meeting in New York, on Monday, the following were elected Directors:—Sir Donald A. Smith, K.C.M.G., Mr. W. C. Van Horne, Mr. C. R. Hosmer, and Mr. Thomas Skinner (London).

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The ninth ordinary general meeting of this Company takes place on Thursday, the 29th inst., at Cannon-street Hotel. The Directors' report and accounts will be issued next week.

DEVON AND CORNWALL ELECTRICITY SUPPLY COMPANY (LIMITED).—This Company announce the issue of 14,900 ordinary shares of £5 each, and 100 founders' shares of £5 each. The ordinary shares are payable: 10s. on application; 10s. on allotment; £1 on August 1, 1890; £1 on November 1, 1890; and the balance, in instalments not exceeding £1 per share, at intervals of not less than three months. The founders' shares are to be paid in full on allotment. This Company has been formed for the purpose of establishing, in the principal towns of Devon and Cornwall, central stations, at which electricity can be generated on a large and economical scale. The first centre of the Company's operations will be Plymouth, from which the Company expect a considerable revenue. The station will be of similar construction to that of the House-to-House Electric Light Supply Company at Kensington; but the Company will be perfectly free to acquire and use any improved apparatus or method. The prospectus further states that the Directors have obtained the consent of the local authority at Plymouth to the granting, by the Board of Trade, of a Provisional Order to the Company. The subscription list opened on Tuesday last, and closes this day (Friday), at 10 a.m. The Secretary (*pro tem.*) is Mr. George Murray, and the temporary offices are at 2, Courtenay-street, Plymouth.

ELECTRIC AND GENERAL INVESTMENT COMPANY (LIMITED).—The prospectus of this Company was issued yesterday (Thursday). The capital is £200,000 in shares of £5 each, of which 100 are founders' shares and the balance ordinary shares. The present issue is for £100,000 in ordinary shares, and £500 in founders' shares. The latter have already been subscribed for, but no preference is to be given to the holders of the founders' shares in the allotment of 20,000 Ordinary shares now being made. 10s. per share is to be paid on application, and 10s. on allotment, beyond which no call is at present to be made. The Chairman of the Company is the Duke of Marlborough, and amongst the Directors is Mr. Emile Garke, the manager of the Brush Company. The Secretary is Mr. J. Cecil Bull, and the offices are at 1 and 2, Great Winchester-street, E.C. The prospectus states that the Company has been formed primarily for the purpose of facilitating the promotion and development of undertakings for electric lighting, traction, transmission of power, and for other industrial uses of electricity. The Company has no intention to compete with the existing electrical firms and companies, but to aid and assist them in developing an industry which at present has practically an unbounded scope. The Company does not propose to manufacture any electrical appliances. The principal sources of profits are expected to be commissions on underwriting; profit on acquisition and realisation of concessions, &c.; remuneration for services in examining, reporting on, and assisting the promotion and development of electrical undertakings. The subscription list closes this day (Friday) at four p.m. for town and country.

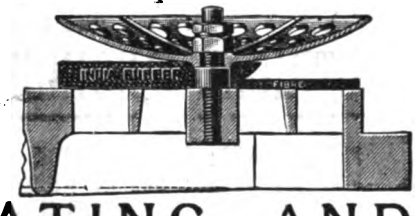
FERRO-TYPE AUTOMATIC PHOTOGRAPH COMPANY (LIMITED).—This is the name of a new Company about to be launched with a capital of £75,600 in £1 shares. Amongst the advantages claimed for the Company's process is that the electric light is applied automatically to the "penny-in-the-slot" machines, so that photographs can be taken by night as well as by day.

HORNSBY AND SONS (LIMITED).—The following interim dividends were declared at a meeting of the Directors:—2s. 9d. per share on ordinary shares for the half year ended March 31, 1890; and at the rate of 6 per cent. per annum on Preference Stock for the half year ended June 14, 1890, both payable on June 14th.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 16th, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £2,896.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 20th Sept. 1886.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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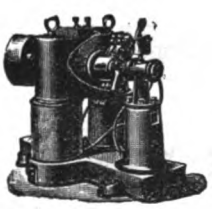
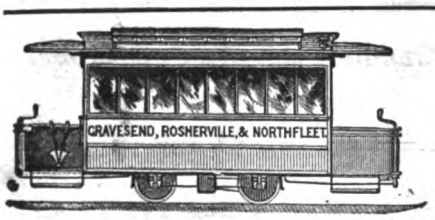
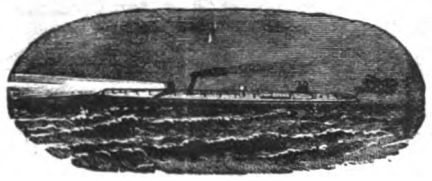
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 14.		Price Wednesday, May 21.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 21.	
£			**TELEGRAPHS.**					£ s. d.		Highest.	Lowest.
1,381,330	Stock	12/6	Anglo-American	50	51	50	51	5 7 10	Jan., Apr., July, Oct	50½	..
2,809,310	Stock	25/0	Do. Preferred	85	86	86	87	6 6 5	" "	86⅜	85½
2,809,310	Stock	..	Do. Deferred	15	15½	15¾	16¼	..	February	16	15⅜
25,000	£100	4%	African Direct, 4 per Cent. Debentures	98	101	98	101	3 19 3	January and July	..	..
130,000	10	3/0	Brazilian Submarine	12	12½	11⅞	12¼	6 2 5	Mar., June, Oct., Dec.	12 7/8	11¾
69,200	100	5%	Do. 5 per Cent. Bonds	101	103	101	103	4 17 1	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	105	108	106	109	4 11 9	June and December	..	..
16,000	10	9/0	Cuba Submarine	11	11¼	11	11½	7 16 6	February and August	11⅝	..
6,000	10	10%	Do. Preference 10%	17½	18½	17½	18½	5 8 1	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3¾	4¼	3¾	4¼	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
80,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 14 11	Jan., Apr., July, Oct	10⅝	10
400,000	10	2/6	Eastern	13⅜	13½	13⅝	14	4 12 10	" "	13⅝	13 1/16
70,000	10	6%	Do. 6 per Cent. Preference	14½	15½	14½	15½	3 18 8	" "	15⅝	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107	110	107	110	3 12 9	May and November	109½	108½
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	107	110	107	110	4 10 11	February & August	..	..
250,000	10	6/6	Eastern Extension	13⅛	13¾	13¼	13⅜	5 1 10	Jan., Apr., July, Oct.	14	12⅞
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	101	103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 per Cent. (Aust n. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	102	105	102	105	4 15 3	" "	..	..
180,227	10	2/0	Globe Telegraph and Trust	8⅜	8¾	8⅜	8¾	5 12 8	Jan., Apr., July, Oct.	8 1/16	8⅝
180,042	10	6%	Do. 6 per Cent. Preference	14¾	15	14¾	15	4 0 0	" "	14⅞	..
150,000	10	5/0	Great Northern	15½	16	15½	16	4 13 6	Jan., July, and April	15⅝	15⅜
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102	105	102	105	4 15 3	January and July	103	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	38	40	38	40	6 5 0	April and October	39½	38
33,348	10	4/0	London Platino-Brazilian xd	6	7	6	7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅜	8	7⅜	8	5 0 0	April and October	..	..
3,391	£100 Cert.	..	Submarine Cables Trust	110	115	110	115	5 4 4	" "	114	..
15,609	£10	3/6	West African	9	10	9	10	..	..	10	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	99	101	4 18 0	March & September	..	..
30,000	10	5/0	West Coast of America	6	7	5¾	6¼	7 13 10	January and July	6½	6
150,000	100	8%	Do. Debentures 8%	117	122	117	122	6 11 2	June and December	119	..
88,321	10	Nil.	West India and Panama	2⅜	2⅝	2⅜	2⅝	..	..	2⅝	2½
34,563	10	12/0	Do. 1st Preference 6% xd	11½	12	11	11½	5 4 4	April and October	11½	11
4 669	10	10/0	Do. 6 p. c. 2nd Pref..... x 27/6 on a/c arrears	14	15	12½	13½	..	..	..	..
64,572	15	6/0	Western and Brazilian xd	10½	10⅞	9¾	10¼	..	May and November	10	9⅞
26,986	7½	6/0	Do. 5 per Cent. Cumulative Preferred .. xd	6⅜	7	6¼	7	..	..	6⅞	..
26,986	7½	7/6	Do. 5 per Cent. Deferred xd	4	4½	3⅞	4⅛	..	..	3⅞	3¾
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	123½	123
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	5%	Consolidated Telephone Const. and Maintenance	7/16	1/4	7/16	1/4	..	Yearly	1/2	..
220,000	£1	3%	Oriental (11s. paid)	3/8	1/2	3/8	1/2	4 8 3	Yearly	..	..
336,875	5	3/0	National	5⅛	6	5⅛	6⅛	..	June and December	6 1/16	5⅞
49,825	5	..	Do. New xd	5⅛	6	5⅛	6	..	..	5⅞	..
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference	12½	12⅞	12½	13¼	4 14 1	June and December	..	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference	10	11	10½	10⅞	..	" "	..	..
209,750	1	..	South of England, Ordinary	1/16	1/8	1/16	1/8	..	..	..	..
20,000	5	1/0	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3¼	3½	3¼	3½	6 0 0	..	..	..
55,000	5	2/0	United River Plate	4⅜	5	4⅜	5	..	January and July	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..	..	..	..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2¾	2⅞	2⅜	2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5½	5⅝	5	5⅛	..	..	..	..
42,853	5	..	Westminster Electric Supply	1⅝	2	1⅞	2¼	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅛	2¼	2⅛	2⅜	..	..	2 1/16	2⅛
63,416	2	1/2	Do. Preference	1⅝	1⅞	1⅝	1⅞	6 8 0	..	1⅞	1⅝
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares	5¼	5½	5¼	5½	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
409,000	10	..	Electric Construction	9¾	10¼	9¾	10¼	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5	5¼	4¾	5¼	..	..	..	..
20,000	5	..	Fowler-Waring Cables	2¼	2⅜	2¼	2⅜	..	..	5 1/16	5⅛
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18	19	18½	19½	..	February & August	19	18½
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	4¾	5⅛	5	5⅛	..	..	5 1/16	5⅛
37,350	12	30/0	Telegraph Construction and Maintenance	44	46	44	46	5 3 11	March and July	46⅜	45
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	..	..	..







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FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 628.—Vol. XXV. FRIDAY, MAY 30, 1890. Price Fourpence.

NOTES.

The Intercolonial Conference on Postage and Cable Rates has agreed to Sir John Pender's latest proposal in respect to the Australasian cable rates, namely, 4s. per word for ordinary telegrams, 3s. 6d. per word for Government telegrams, and 1s. 10d. per word for Press telegrams. The only point which now remains to be settled is, whether or not the Imperial Government will share the cost of the subsidies and guarantees payable by the Colonies to the Companies. We trust that an arrangement of such supreme importance to the mercantile community, and which has been carried through so far in such a satisfactory manner, will not be allowed to end abortively on account of the comparatively minor point still at issue.

Our esteemed contemporary the *Electrical World* of New York is considerably alarmed at a carbon brush patent which has been issued to Prof. George Forbes by the United States Patent Office, and is of opinion that it "opens up as magnificent a field for interference suits as the most litigious inventor could desire." The English patent is No. 1,288 of 1885, and states that with a view of diminishing the friction and consequent wearing away and heating which generally result when contact is made by metal surfaces in relative motion, it is proposed to employ carbon blocks; plates, such as are used in galvanic batteries, with a backing of copper, being preferred. The claims are four in number, the last being for "the combination with a dynamo machine of a collector, consisting of a surface of carbon and a metallic surface maintained in electrical connection therewith, whilst the said surfaces are in rapid relative motion."

The Halifax-Bermuda cable which was shipped away from the Thames one day last week takes with it the best wishes, not only of its friends and promoters, but of all well-informed and patriotic Englishmen. Two important naval and military outposts of the British Empire will, if the enterprise succeed, be linked together, with great advantage to their mutual security, and perhaps also a little to their commerce. But as regards the latter a lively imagination is required to discover ground for large expectations; the *Morning Post*, however, is equal to the task. Commenting on the probable results of laying this cable, our contemporary reminds us that a good deal of garden-stuff is grown in Bermuda, and that a famous lily flourishes there, the bulbs and blossoms of which are in much demand. The climate also is said to be good for sick Americans; and although it cannot be exported for their benefit they can be imported into it, and will be attracted to it the more by being able to send cablegrams homewards. We sincerely hope so; but, if we were a shareholder, our chief reliance would be placed on the £8,000 a year subsidy.

In 1887 M. Paul Janet showed that cylinders of steel, along which strong currents had been passed, became permanently magnetised transversely. By extending the experiments some very striking results have been recently obtained by M. Decharme, who has described them in the *Comptes Rendus* and *La Lumière Electrique*. The cylinders used were split longitudinally; and, after the passage of the current, the magnetism of the parts was tested by iron filing figures. It was then evident that not only was the iron magnetised transversely, but the intensity of the magnetisation varied in a regular undulatory manner along the bar, the lines of force arranging themselves in somewhat the same way as fine powder in a vibrating tube. The effects could not be accounted for by supposing the iron heterogeneous, because the nodes and loops occurred at about the same distance for different bars of various diameters and lengths. M. Decharme concludes that there is a great difference in the magnetisation of an iron core by a steady current passed through a solenoid surrounding it, and that of an iron bar through which a current actually passes. In the latter case, M. Decharme considers that the current is propagated in waves during the very short time necessary to produce the magnetisation, and compares the phenomenon with the well-known undulatory magnetism produced by the oscillatory discharge of a Leyden jar. The effect is probably due to the starting of the current, and it is therefore unfortunate that no particulars are given of the manner in which this was done—whether switched on suddenly or increased very gradually to its full value. In the latter case, no effect might have been produced, as strong currents were needed to show the phenomenon. The experiments of Blaserna have shown that undulations do actually occur for the first few moments after starting a current, and it is possible that these may be much accentuated when part of the conducting circuit is of iron. The experiments are of interest because they suggest that many phenomena usually attributed to want of homogeneousness in iron may really be due to successively starting and stopping a magnetising current.

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A NEW form of electric chronograph, due to the Rev. F. J. SMITH, is described in the May number of the *Philosophical Magazine*. The instrument is original in many respects, although the time traces are made by means of electro-magnetic styli, as is the case in many other forms of time-measuring apparatus. The principle involved in the construction is that of ATTWOOD'S machine. A carriage, to which a sheet of smoked glass is attached, is impelled horizontally by means of a cord attached to a weight. The weight, after acting through a certain length of fall, is arrested by means of a table of adjustable height, and the carriage moves on with an acquired velocity which is found experimentally to be constant during the whole length of a trace.

FOR the details, which are of an elaborate character, and have been worked out with great care, we must refer our readers to the original article. There are, however, some points deserving of special mention. A serious source of error arises in nearly all chronographs in which electro-magnets are used for making the records, and is due to the fact that the armature does not detach itself immediately on the stoppage of the magnetising current, or even at a constant period afterwards. The interval of time in some cases, where much iron is employed, may be as much as 0·04 second, and Mr. SMITH found that two apparently similar magnets differed in their action by some hundredths of a second. This difficulty has to a great extent been surmounted by properly proportioning the dimensions of the core and yoke, by carefully selecting the material of the core, and by modifying the winding. After much experimenting it was found that the yoke should be made large compared with the cores, the proportions finally adopted being 2 mm. diameter and 10 mm. long for the cores, and 5 mm. square by 20 mm. for the yoke. By these means the time interval, to which the appropriate name of *latency* has been given, was reduced to 0·0003 seconds, and, what was even more important, the interval was found to be the same for different styli constructed on the same lines. The reduction of the latency not only removes an uncertain source of error, but renders the marking more definite and readable, so that the accuracy of the apparatus is much increased.

THE method by which the time traces are preserved also deserves mention. No injury to the traces was found to occur when the smoked glass was covered with photo varnish, provided first a mixture of the varnish with 25 times its volume of strong methylated spirit is poured over the plate and allowed to dry. After the application of the thicker varnish the traces can be used as negatives in the usual way.

IN our list of new companies this week will be found one entitled the General Electric Power and Traction Company, which proposes to work under agreements with the Electric Traction Company, Messrs. Immisch and Co., and the Electric Construction Corporation. Is it too much to hope that some solid progress in electric traction will result from this rearrangement?

Canterbury.—The Town Council have determined to apply for an electric lighting Provisional Order.

Electrical Execution.—The Supreme Court of the United States has refused an application for a writ of error in the Kemmler electrical execution case.

The International Telegraph Conference.—On Wednesday evening Sir John Pender gave a dinner to the delegates of the Conference at the Pavillon d'Armenonville.

Electrical Bills in Parliament.—The North Metropolitan Tramways Bill and the City of London and Southwark Subway Extension Bill were read a second time in the House of Lords on Thursday last week.

Civil and Mechanical Engineers' Society.—A visit was made by this Society to Henley's Telegraph Works at North Woolwich on the 16th inst., and the visitors were shown the whole operation of cable making.

Military Telegraphy.—Orders have been given from the War Office for the Telegraph Battalion of the Royal Engineers to form a camp at Lyndhurst during the summer, and the Army Reserve Telegraphists attached to the Post Office Volunteers have been directed to join the camp by successive parties.

Weston-super-Mare.—The Western Counties Telephone Company are making rapid progress with their work in Weston-super-Mare. Thirty subscribers are already connected with the central exchange, and in the course of a few weeks the trunk line, which will connect Weston-super-Mare with Bristol and other places, will be complete.

Post Office Jubilee Conversazione.—Arrangements are being made for holding a *conversazione* at the South Kensington Museum on Wednesday, July 2nd, in aid of the Rowland Hill Benevolent Fund, and in celebration of the Jubilee of Uniform Penny Postage. The 2nd of July will be a general holiday in the Post Office, so far as the due administration of the public service will permit.

Charging Accumulators by Alternating Currents.—At the meeting of the Elektrotechnischen Verein on April 22nd, Dr. Föppl, of Leipzig, gave a description of an apparatus for charging accumulators by alternating currents. The apparatus has a shaft revolving in synchronism with the period of alternation, which at every instant throws into circuit a certain number of the secondary cells.

Cambridge.—The Town Council have taken the first step towards carrying out the powers with which they have been invested by the Provisional Order granted them by the Board of Trade. On the recommendation of the Electric Lighting Committee, they have resolved to enter into a provisional agreement for the purchase of a site, at a cost of £1,041, on which to erect a central station.

Electric Car Statistics.—It is worth noting that the four electric cars running on the Barking-road for the North Metropolitan Tramway Company, carried on Monday last 8,689 passengers, an average of 2,172 per car, and earned £9. 1s. each. During the three days, Saturday, Sunday, and Monday 20,104 passengers were carried, which, we understand, is the highest record of the Company for this section of their line.

Heavy Thunderstorms.—During a terrific thunderstorm at Barnstaple last Sunday Holy Trinity Church was struck by lightning, one of the pinnacles of the tower being overthrown. A similar occurrence took place at Holsworthy, Cornwall. The lightning displaced the north pinnacle of the tower of the parish church, and portions of the *débris* fell through the roof. A few miles from Exeter several houses were struck and cattle and sheep were killed by lightning.

The Clerk-Maxwell Scholarship.—The amount bequeathed to the University of Cambridge by Mrs. Clerk-Maxwell, to found a scholarship in the Cavendish Laboratory at Cambridge, has been realised, and shows available for this purpose £5,963, with accruing interest on the sum of £5,000, on deposit with the National Bank of Scotland. The scholarship will be founded for the advancement of original research in experimental physics, and especially in electricity, magnetism, and heat.

Woking.—The Parochial Committee of Woking have decided to ask the permission of the Rural Sanitary Authority to enter into negotiations with the local Electric Lighting Company,

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with a view of coming to some arrangement for the lighting of the streets. The Company have offered to erect and maintain, free of cost to the Authority, lamp-posts and supply current for 16 candle-power lights at a cost of £3. 10s. per lamp per annum; not less than 50 lamps to be taken in the first instance.

Telegraphic and Telephonic Extensions in Germany.—A State grant of 8,000,000 marks has just been made for the extension of the telegraph and telephone lines in the German Empire. Of this, 3,099,550 marks are to be devoted to the town telephones already existing, 606,000 marks to the erection of new ones, 1,928,000 marks to new telegraph lines, principally in the country, 761,900 marks for improvements in, and 87,500 for extensions of the pneumatic postal services in Berlin and Hamburg.

Bicycles for Telegraph Messengers.—The Postmaster-General is said to be greatly struck with a suggestion which has reached him for the improvement of our telegraphic service, this being to the effect that for the readier delivery of telegrams the boy messengers should use bicycles. The scheme would not (as the London correspondent of the *Birmingham Post* reminds us) be very suitable for cities having roughly-paved streets; but in London, where there is so much wooden pavement, it might answer very well. Several telegraph messengers in the metropolis have, indeed, already experimented with bicycles on their own account.

Report of the Comptroller-General of Patents.—The report of the Comptroller-General of the Patent Office on Patents, Designs, and Trade Marks was published on Wednesday in the form of a Parliamentary Paper. The number of applications for patents in 1889 was 21,008, as against 19,103 in 1888, and 17,110 in 1884. The receipts from patent fees during 1889 were £151,794. 4s. 4d. The total receipts were £172,820. 18s. 6d. The expenses amounted to £79,286. 9s. 9d., of which the two chief items were £49,086. 0s. 11d. for salaries and £18,200 for printing and lithographing. The surplus for the year was £93,534. 8s. 9d.

The Lane-Fox Patents.—The Lane-Fox Electrical Company have commenced negotiations with various supply companies with a view to the granting of licences and the payment of royalties under the electrical distribution patents held by them. Three methods of payment are proposed:—1. By a charge of 1d. per Board of Trade unit supplied to consumers. 2. By a charge of ½d. per unit, such payment to continue after the expiration of the licence for such a term as would render the payment equivalent to No. 1. 3. By a capitalised sum, payable partly in cash, partly in shares. An indemnity is also offered for having used the patents prior to December 31, 1889.

The French Exhibition.—As we mentioned some time ago the lighting of this Exhibition has been entrusted to the Gülcher Company. Steam is supplied from three 40 horse-power nominal Davey Paxman boilers, to two Davey Paxman engines of 200 and 130 horse-power respectively, and to a 80 horse-power Ruston and Proctor engine. The power from the engines is transmitted to countershafting. There are ten dynamos in all, namely, four 40-unit Battersea compound-wound dynamos, four 20-unit Battersea dynamos, one 2-pole 20-unit machine, and one 4 pole 30-unit machine. The lamps are all arranged in parallel, on 70-volt circuits, resistance coils being placed in series with each lamp.

Bolton and its Electric Lighting.—It is scarcely to be wondered at, says the *Electrical Review* of New York, that electric lighting does not make more rapid progress in England than has been the case hitherto. The Corporation of Bolton, a thriving industrial town in Lancashire, recently issued 1,178 circulars in connection with the proposed introduction of the electric light. Only 449 replies were received; of these but 45 (including one very large and important firm) desire the electric light; 24 wish for it if the price is the same as gas; 56 are uncertain by reason of the cost; 30 are doubtful, and 314 convey an absolute negative. In face of such deadly conservatism as this, what can electricians do?

The Clermont-Ferrand Electric Railway.—This line, which is about four and a-half miles long, connects Clermont-Ferrand with Royat-les-Bains. The cars are 40ft. long, and carry 50 passengers; they are worked by 40 horse-power motors, Vaucanson chain gearing being used. The current is supplied at a difference of potential of 300 volts. An overhead conductor run on 26ft. iron posts with rail return is used. This conductor is a slotted copper tube of rectangular section, and is supported by a ·8in. steel cable. The sliding contact is 16in. long, and consists of a string of bronze balls connected to one another and to the car by a metallic wire. The line is a single one, and passing places are provided at each of the six intermediate stations.

Arc Light Formula.—Mr. Tischendörffer, of Vienna, gives a formula for the relation between current and lighting power for arc lamps. He says that L being the lighting power, and C the current, $L = 100\left\{C + \left(\frac{C}{4}\right)^2\right\} - 200$. This gives the following values:—

C	L	C	L
2	25	16	3,000
4	300	18	3,625
6	625	20	4,300
8	1,000	30	4,825
10	1,425	40	13,800
12	1,900	50	20,425
14	2,425		

The Lighting of the Paris Exhibition.—During the Paris Exhibition M. Brault with a Weber photometer, and MM. de Nerville and Lepage with a Mascart photometer, made a number of photometric observations, in order to arrive at the actual average luminous intensity in various parts of the Exhibition. On the floor of the Palais des Machines the average intensity was 3 carcels per square metre (1 carcel per square metre = ·9 candle-power per square foot) according to M. Brault, and 1·97 carcels per square metre according to MM. de Nerville and Lepage. Under the central dome the average intensity was ·5 carcel per square metre; in the entrance-hall of the Palais des Machines, ·3 carcel per square metre; in front of the cafés and restaurants, 1 carcel per square metre; at the Porte Rapp, 7 carcels per square metre. In the gardens the average estimated intensity was only ·1 carcel per square metre.

"L'Elettricita."—In answer to the questions recently propounded by the editor of *L'Elettricità* Prof. Elihu Thomson replied that the most important discovery during 1889 was that of Hertz. In the present year he believed that the application which will receive the greatest amount of attention will be electric traction, and the transmission of energy. Dr. O. Fröhlich confessed that he did not like to risk an answer. He had always, he said, found it impossible to predict developments in electricity. Prof. Houston thought that the answer to question 1 was to be found in the improvements that have taken place in accumulators. With regard to question 2, he considered that distribution systems and the direct production of electric energy from coal would make the greatest progress. M. Maurice Levy was of opinion that the Desrozier dynamo would make the greatest progress. Among the answers published there were no English and only one German name.

Conference of Telegraphists.—On Wednesday night a meeting of the telegraph staff of the London Post Office was held in the Foresters' Hall, Clerkenwell-road, to make arrangements in connection with the Conference of the Postal Telegraph Clerks' Association, to be held at Leicester on Saturday. The first resolution which was passed provided that ten delegates should be sent to the Conference from London, six male and two female members of the Central Telegraph staff and two from the Metropolitan district offices. As a proposition to be submitted to the Conference, a resolution was adopted to the effect that, as the Postmaster-General now stated that he brought no charge against the men exiled from Cardiff, a united request, signed by every member of the Association, should at once be made to the Postmaster-General for their reinstatement. During the evening a telegram was received from Sir John Puleston, expressing gratification that full pay on sick leave had been conceded.

University College, Cardiff.—In connection with the advertisement, which will be found in another column, with regard

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to the Professorship of Mechanical Engineering, about to be established at the University College of South Wales and Monmouthshire, Cardiff, we understand that the Council have been anxious since the opening of this College in 1883 to add a Department of Engineering which should be worthy of the great interests in its immediate neighbourhood. Thanks to the generosity of the Drapers' Company and of several prominent local men, this scheme will now be realised. Besides the appointment now advertised we learn that a Lectureship in Mining Engineering will also shortly be established. Electrical engineering is also to receive attention; and in order that this may be done in a thoroughly practical manner it is intended to provide a miniature central lighting station. It is expected that the above arrangements will be sufficiently advanced to enable a start to be made in October next, and it is hoped the number of students in attendance at the various classes will amply justify the Council in the course they have taken.

The Schiseophone.—This instrument, which is due to Captain du Place, is, like the "electric acoumeter" described in our issue of May 23rd, merely a modification of Prof. Hughes' sonometer. The object of the schiseophone is to facilitate the detection of flaws in metal bars, &c.; and according to our French contemporaries some recent trials of this apparatus at the Ermont workshops of the Northern Railway of France have proved it to be practically useful. The instrument comprises a striker and an audiometer. A steel rod is moved to and fro in front of a microphone, periodically striking the metal bar under examination. Two coils, one movable and connected to the microphone, the other fixed and connected to two telephones, are arranged on a graduated rod. Having placed the movable coil so that the telephones are silent so long as the hammer is striking a solid portion of the metal, the hammer is moved along the bar, and should there exist a flaw in it the increased noise given out causes more powerful currents to flow in the microphone circuit, with the result that the telephones are no longer silent.

Paddington Vestry.—A special meeting of this Vestry was held on Thursday to pass the resolution required by the Board of Trade prior to the Board formally granting a Provisional Order to the Metropolitan Electric Supply Company. Mr. Mark H. Judge contended that the meeting was not called in accordance with the rules of the Board of Trade, and asked the Chairman to rule it out of order. After some discussion, the Chairman ruled that the meeting was properly called. On the resolution being put 37 voted for and 19 against it.—A further special meeting, called by Mr. Mark H. Judge, Mr. C. A. Stephenson, and others, was then held, the notice calling the meeting to take into consideration the result of the meeting called for the same morning, and to decide what further action the Vestry should take consequent on the result of the above described meeting. The Chairman ruled the motion out of order, and Mr. M. H. Judge then said he would call the attention of the Board of Trade to the irregularity of the morning's proceedings. A further complication is possible, owing to the fact that the resolution passed does not specifically refer to the Provisional Order as amended by the Vestry, and the one actually before the Board of Trade differs in several respects from that agreed to by the Vestry.

The Birmingham Exhibition.—The committee of this Exhibition have sent a cheque for £101. 7s. 2d. to each of the three Birmingham hospitals, to which the surplus of the receipts of the Exhibition was to be given. The closing of the accounts was prevented, it is stated, by a threatened lawsuit involving a large sum of money. As soon, however, as an arrangement was come to the committee were able to deal with the balance of the funds. The accounts have been audited by a chartered accountant, but on the ground of expense it is not intended to publish them; though, if desired, they can be seen with all the accompanying papers at the office of the Secretary, Mr. T. C. Sharp. The following figures were, however, supplied to the *Birmingham Daily Post* by Mr. Sharp:—The total receipts were £12,059. 14s. 5d. The particulars of the expenditure are: Fitting up hall, £3,856; rent and insurance, £769; bill-posting, £1,815; band and entertainments, £1,300; coal and water, £272; law expenses (including £55 10s. paid to settle the claim), £255. 10s.; medals, £75. 10s. These items, with the £304 divided among the hospitals, make up a total of £8,647. There is thus a balance of £4,412, which is accounted for by salaries, wages, royalties, bank charges, professional charges, travelling expenses, carriage, and other items, of which the details are not given.

The Laurent-Cely Accumulator.—The special features of the Laurent-Cely accumulator, which is constructed by the Société Anonyme pour le Travail Électrique des Métaux, consists, says *Engineering*, in the special nature of the lead paste employed, and in the manner in which it is applied to the plates. The active element is a mixture of chloride of lead and chloride of zinc. The fused chloride of lead has a density of 5·6; by incorporating chloride of zinc with it in certain proportions the density is reduced to 4·5. This mixture, brought to a state of fusion, is run into cast-iron moulds in the form of small buttons with rounded edges. After cooling, the buttons are washed to remove the chloride of zinc, and thus to render them somewhat porous. Their density then varies from 4·2 to 3·4. The buttons which serve for the manufacture of the negative plates are then arranged in a metallic mould, into which antimonial lead is run; this surrounds the buttons with a frame which holds them fixed in their positions. The negative plates are mounted in cells filled with acidulated water and provided with zinc electrodes. The composite and zinc plates are then short-circuited. The hydrogen which is disengaged upon the positive electrode reduces the chloride of lead, and there are thus obtained buttons of spongy lead of a density between 2·5 and 3·1, while that of ordinary lead is 11·35. The buttons used in the manufacture of the positive plates are first transformed into spongy lead, then heated in the air to oxidise them, and transformed into spongy litharge. They are fixed, like the negative buttons, in a frame of antimonial lead. The Laurent-Cely accumulator is employed for the lighting of the *wagons lits* on the Chemin de Fer du Nord, and has also served to drive a motor working an electric capstan.

Electricity Behind the Stage.—In a recent issue of the *Electrical World* there is an interesting account of the manner in which electricity is called into play to produce a realistic representation of a horse race in "The Country Fair" at the Union Square Theatre, New York. The electric lights are flashed out, and after a few moments of darkness the flying horses appear at the back of the stage in a blaze of light. They seem to be straining every nerve, and flying past a varied landscape. Fences and trees disappear behind them with startling rapidity, and when at last the finish is near one of the horses gradually works forward, winner by a neck as he approaches the judges' stand; then an instant of darkness, and in the flash of light that follows the horses are pulled up beyond the stand, and the race is won. The picket fence behind which the horses appear to be running, and the varied scenery that is beyond, are both set in motion by the judicious application of the electric motor. Both fence and scenery form endless belts, which move at the same speed past the horses, producing the effect of rapid motion of the animals in a contrary direction. The fence in the foreground runs over flanged wheels specially adapted for the purpose, and has guides that hold it rigidly perpendicular during its passage over the stage. As the race nears the finish, the platform on which the winning horse is stationed is gradually slipped forward on a track provided for the purpose until the finish, the actual movement being, of course, only a few feet. The space between the fence and the scenery behind is 14ft., giving ample room for free action of the horses. Much of the effect of the scene is due to the extreme suddenness with which the electric lights can be flashed off and on, throwing the stage from extreme darkness to brilliant light and back again in an instant, so that the whole scene appears as a vivid panorama before the audience. A switchboard on the left of the stage enables one man to control the lights and the mechanism by which the scene is given, and this is in part the reason why electricity has been used so freely. It is proposed to still further increase the application of motors at this theatre, and so to arrange things that, as far as possible, all mechanical devices and moveable scenery will be handled by motors from one point with great rapidity, and without the danger of trouble from careless attendants.

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MAGNETISM IN IRON AND OTHER METALS.*—XIX.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 58.*)

§ 79. Dissipation of Energy through Magnetic Hysteresis.—One very important consequence of magnetic hysteresis is that changes of magnetisation (on the part of iron and the other magnetic metals, all of which exhibit hysteresis) involve a dissipation of energy. When the magnetism is carried through a cyclic series of values, the curves showing the relation of I to H form a loop, and the area of that loop, in other words, the integral $\int \mathsf{H}\, d\,\mathsf{I}$, measures the amount of energy dissipated during the cycle through hysteresis.†

Perhaps the simplest way to prove this is to think of the magnetisation as being produced by a current in a magnetising solenoid, and to consider the work done by the current when the magnetism changes. To fix the ideas, take as the core of the solenoid a ring or very long rod, of length l and cross-section s, wound with a solenoid of n turns per centimetre, so that the whole number of turns is ln. Say that its magnetic induction is increased by an indefinitely small amount, $d\,\mathsf{B}$, in an indefinitely small time, dt, by increasing the magnetising current to an indefinitely small extent. Then the whole number of lines of induction within the solenoid is increased by the number $s\,d\,\mathsf{B}$, and the time-rate of this increase is $s\frac{d\,\mathsf{B}}{dt}$. This induces in the surrounding solenoid an electromotive force equal to $l\,n\,s\frac{d\,\mathsf{B}}{dt}$ in the direction opposite to that of the current. The current has accordingly to do work in overcoming this opposing electromotive force, over and above whatever further quantity of energy it expends in heating the conducting wire. With this last source of loss we need not concern ourselves: we wish to find the energy which is spent in producing magnetisation. Let C be the mean value which the current has during the time dt. The opposing electromotive force, due to the change of magnetic induction in the core, when multiplied by the current and by the time dt, gives the quantity of work done by the current. Hence the work done by the current in producing the change of magnetism $d\,\mathsf{B}$ is

$$l\,n\,s\frac{d\,\mathsf{B}}{dt}\,\mathrm{C}\,dt, \text{ or } l\,n\,s\,\mathrm{C}\,d\,\mathsf{B}.$$

The fact that dt disappears shows that this work does not depend on the time-rate at which the change of induction takes place; we have the same quantity of energy used in the process whether the change $d\,\mathsf{B}$ takes place fast or slowly. Since the volume of the core is ls, we may write $d\,\mathrm{W}$, the work done by the magnetising current per unit of volume (that is, per cubic centimetre), in bringing about the change $d\,\mathsf{B}$, as

$$n\,\mathrm{C}\,d\,\mathsf{B}.$$

But the magnetising force H is $4\pi\,\mathrm{C}\,n$, hence

$$n\,\mathrm{C} = \frac{\mathsf{H}}{4\pi}, \text{ and } d\,\mathrm{W} = \frac{1}{4\pi}\,\mathsf{H}\,d\,\mathsf{B}.$$

To obtain the work done per cubic centimetre of the metal when B is changed by any finite amount by changing the magnetising force from (say) a value H_1 to another value H_2 we have to integrate this expression, finding

$$\mathrm{W} = \frac{1}{4\pi}\int \mathsf{H}\,d\,\mathsf{B}$$

between the limits H_2 and H_1.

Thus, in Fig. 46, if P and Q are any two points in the curve of B and H, the work done per cubic centimetre as the magnetic state alters from P to Q is the area M P Q N divided by 4π. For example, in magnetising a piece which has no magnetism to begin with, the curve followed being O P (Fig. 47), the work done in reaching P is equal to the area O P M divided by 4π. If we then remove the magnetising force (curve P R) we *recover* a quantity of work equal to the area R P M, divided by 4π; the net expenditure of energy in the whole process is, therefore, equal to the shaded area O P R, divided by 4π.

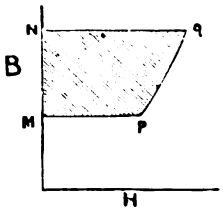

Fig. 46.

In this case the final state of the metal at R is different from its initial state at O, and it is therefore not immediately obvious how much of this energy has been spent irrecoverably. But let a *cyclic* process be followed, so that at the end the magnetisation, as well as the magnetising force, is brought back to the value it had at the beginning; in that case there can be no accumulation of recoverable energy at the end of the cycle.

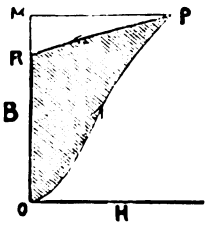

Fig. 47.

The whole difference between what is spent during one part of the process and what is recovered during the other part is therefore *dissipated*, and simply goes to heat the metal. Thus, when we carry the metal through cyclic magnetic changes such as are represented in Fig. 48, where the magnetising force is removed and reapplied, or in Fig. 49, where it is reversed and

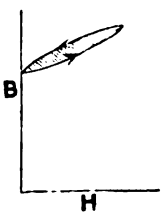

Fig. 48.

re-reversed, there is a quantity of energy dissipated in each cycle per cubic centimetre of the metal equal to $\frac{1}{4\pi}\int \mathsf{H}\,d\,\mathsf{B}$; in other words, it is equal to the shaded area enclosed by the curves connecting H and B, divided by 4π.

Moreover, since $d\,\mathsf{B} = 4\pi\,d\,\mathsf{I} + d\,\mathsf{H}$,

$$\frac{1}{4\pi}\int \mathsf{H}\,d\,\mathsf{B} = \int \mathsf{H}\,d\,\mathsf{I} + \frac{1}{4\pi}\int \mathsf{H}\,d\,\mathsf{H}.$$

But in a cyclic process, $\int \mathsf{H}\,d\,\mathsf{H}$ vanishes; and the energy dissipated in a cycle is, therefore,

$$\int \mathsf{H}\,d\,\mathsf{I}.$$

Thus in Figs. 48 and 49, if we represent the magnetism by I instead of by B, the shaded area measures the amount of energy dissipated in each cubic centimetre of the magnetised metal during the cyclic process which the curves represent.

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† This was first shown by Warburg in an important paper dealing with several effects of magnetic hysteresis, *Wied. Ann.*, XIII. (1881), p. 141. He proved it by supposing the magnetic force to depend upon the position of permanent magnets, and calculated the work spent in carrying these magnets through the necessary cyclic changes of position. It was afterwards discovered independently by the writer, who showed that it could be readily deduced from Maxwell's general equations of the electromagnetic field (*Proc. Roy. Soc.*, May, 1882, No. 220, p. 39; *Phil. Trans.* 1885, p. 549). The method of proof followed in the text is substantially Hopkinson's, *Phil. Trans.*, 1885, p. 456; see also Lord Rayleigh, *Phil. Mag.*, Vol. XXII., p. 176.

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As C.-G.-S. units are used in expressing H and I, the area within the curves gives the energy dissipated (per cubic centimetre) in C.-G.-S. units of work, or ergs.

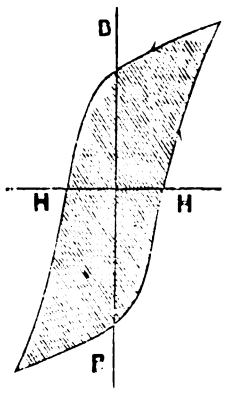

Fig. 49.

§ 80. **Heating Effect of a Cyclic Process.**—The dissipated energy takes the form of heat: hence iron and other metals in which there is magnetic hysteresis become warmed when their magnetism is successively reversed or varied in any way—the effect of reversal being much more marked than the effect of simple removal and reapplication of a magnetising force, because of the much greater area of the reversal loops.

The iron of transformers and the cores of dynamo-armatures are familiar instances in point. The heating which occurs as a consequence of hysteresis has, of course, nothing to do with the additional heating which Foucault or eddy currents may cause when quick changes of magnetism are made to take place in iron which is not sufficiently laminated. Hysteresis causes heating however slowly the magnetism changes, and however minute are the subdivisions of the core.

To find the rise of temperature which a magnetic metal suffers when its magnetism is cyclically varied, we have to reduce the value of $\int \mathsf{H}\, d\,\mathsf{I}$ to thermal units, and divide by the number of grammes in a cubic centimetre, and by the specific heat. Using centigrade degrees, there are 41,600,000 ergs in a thermal unit. In iron, the specific heat is 0·11, and there are 7·7 grammes in a cubic centimetre. Hence, the rise of temperature caused by a magnetic cycle is—

$$\frac{\int \mathsf{H}\, d\,\mathsf{I}}{41{,}600{,}000 \times 7{\cdot}7 \times 0{\cdot}11} = 2{\cdot}84 \times 10^{-8} \times \int \mathsf{H}\, d\,\mathsf{I}.$$

§ 81. **Values of $\int \mathsf{H}\, d\,\mathsf{I}$.**—In soft annealed iron the value of $\int \mathsf{H}\, d\,\mathsf{I}$, for each double reversal of a condition of strong magnetization is about 10,000 ergs. Nearly 4,000 double reversals would therefore be necessary to raise the temperature of a soft iron core by 1° C., if the influence of eddy currents could be excluded.

Since there are 7·7 grammes of iron in 1 cubic centimetre, and 453·6 × 2240 grammes in a ton, the energy dissipated in taking one ton iron through a magnetic cycle is

$$\frac{453{\cdot}6 \times 2240 \times \int \mathsf{H}\, d\,\mathsf{I}}{7{\cdot}7}.$$

Suppose that there are n cycles per second: the work done in ergs per second is then

$$\frac{n \times 453{\cdot}6 \times 2240 \times \int \mathsf{H}\, d\,\mathsf{I}}{7{\cdot}7}.$$

We may reduce this to horse-power by dividing by $7{\cdot}46 \times 10^9$, which is the number of ergs per second in 1 horse-power. Hence the horse-power consumed through magnetic hysteresis when one ton of iron is taken repeatedly through a set of cyclic changes of magnetism at the rate of n cycles per second is

$$0{\cdot}00001769\, n \int \mathsf{H}\, d\,\mathsf{I}$$

Applying this to the case of soft annealed iron, where $\int \mathsf{H}\, d\,\mathsf{I}$ for double reversals of strong magnetisation is about 10,000 C.-G.-S. units, the horse-power per ton, for 100 cycles of double reversal per second, is 17·7.

In harder specimens of annealed wrought-iron the value of $\int \mathsf{H}\, d\,\mathsf{I}$ for a double reversal of strong magnetism may be as much as 16,000. Hardening by mechanical strain increases the area within the curves, as a reference to Figs. 34 and 38 will show. In mild steel Hopkinson's experiments * show that the value ranges from that found in wrought iron up to 40,000 or even 60,000; it increases in a general way with increase in the percentage of carbon, and is greater in specimens which are hardened by quenching than in those which have a lower temper. In high carbon steels the value may exceed 60,000. In pianoforte steel wire 94,000 has been obtained when the metal was annealed, 116,000 when in its commercial state, and 117,000 when hardened by quenching in water from a red heat. Chrome steel (containing about 1 per cent. of chromium) ranged from about 65,000 (annealed) to 167,000 (oil-hardened). In tungsten steel Hopkinson found even higher values; an oil-hardened French specimen containing 3·4 per cent. of tungsten, 0·5 per cent. of carbon, and 0·6 per cent. of manganese, consumed 216,800 ergs, or more than twenty times the amount consumed in soft wrought-iron. The dissipation of energy in a cycle of double reversal is roughly equal to twice the coercive force multiplied by I.

In cast-iron, values of 30,000 to 40,000 appear to be usual; but in one sample of soft grey cast-iron Hopkinson has found so low a value as 13,000. In nickel, a hard-drawn wire gave 25,000, which was reduced to 11,000 when the wire was annealed. Thus the dissipation of energy in nickel when a strong magnetising force is reversed is much the same as that in wrought-iron, the greater coercive force of nickel being counterbalanced by the lower intensity of magnetism it is capable of reaching, even when "saturated."

(To be continued.)

THE CHELSEA ELECTRICITY SUPPLY COMPANY'S STATION AND SUB-STATIONS.

The system of distribution adopted by the Chelsea Electricity Supply Company, in which storage batteries are provided of sufficient capacity to supply the whole demand for current, is worthy of careful study and attention; because, although somewhat complicated at first sight, it is free from the objections which have been so strongly urged against other systems. The continuity of the supply is not dependent upon moving machinery; efficient motors of low cost can be readily employed; the high-tension charging current is not brought near the consumer's premises; continuous service is secured without the necessity for a double staff of attendants, or for running steam plant with uneconomical loads.

We propose now to give a general description of the system adopted by the Chelsea Company, and of their station at Draycott Place and sub-stations in connection with it. Those of our readers who wish to examine into the details of the arrangements and connections are referred to the Paper by Major-General Webber, read before the British Association last year, and reprinted in our columns (*The Electrician*, October 11 and 18, 1889), where diagrams of connections, &c., will be found.

The system consists essentially in the establishment of a number of substations, which are distributed over the area of supply, each furnished with a large storage battery, which is divided into two parts, so that one part may be charged while the other part is feeding the distributing network. At the time of greatest demand both halves of the battery are coupled up in parallel with each other to the distributing network. When being charged the half-battery at each sub-station has its cells coupled in series throughout, and the several substations are also connected in series by the charging cable, so that a high-tension current is employed to effect the charging.

* *Phil. Trans.*, 1885, p. 463.

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The discharging halves of the batteries have their cells coupled in sets of 55 for 100-volt circuit, which are then coupled in parallel to the distributing network. Continuous-current transformers are to be put down at each sub-station, and at the time of our visit the first of these was being arranged for testing. In some tests which have already been made with this machine the efficiency was 75 to 80 per cent. The transformers absorb the full power of the engines and dynamos, and are intended to be coupled to the distributing feeders, parallel with the batteries, at the time of maximum demand during the winter months; they will be regulated so as to work at full load—that is, their E.M.F. will be slightly higher than that given by the batteries, the object of which is to avoid running the engines with light loads, and to maintain the batteries as fully charged as possible. It was stated at the meeting of the Chelsea Company in February last that the coal consumption per Board of Trade unit delivered to the customers was, on the average, about 11lb., which is a much lower figure than that recorded with any other system of supply, and which may be accounted for by the fact that the plant is never running except on full load.

One of the features of the system is that the number of charging dynamos in operation always equals the number of half-batteries being charged. The dynamos and half-batteries are connected all in series, and when a battery becomes fully charged and is cut out of the charging circuit the corresponding dynamo is stopped at the generating station. This will be effected automatically eventually; but at present it is done by the attendant, who sees by his voltmeter and ammeter the moment when a battery is cut out of circuit.

The number of charging dynamos already fixed is five, four in operation (that being the number of sub-stations) and one spare. The dynamos are mounted on the same bedplate and coupled direct to Willans compound engines of G.G. type. Raworth's flexible couplings are employed, and the dynamo spindle is insulated from the engine by the interposition of an ebonite disc and collars. The dynamos are of the Victoria type, giving an E.M.F. at their terminals of about 530 volts and 75 amperes, at a speed of 424 revolutions per minute. The field-magnets of the charging dynamos are excited from a separate dynamo driven by a small engine. The exciting dynamo is compound-wound for constant difference of potential, so that no variation is caused by switching off the magnets of one or more of the charging dynamos. The armatures of the charging dynamos are coupled in series as before explained. A variable resistance is provided in connection with the field coils of each, so that the E.M.F. can be adjusted independently on all the dynamos. When both halves of a battery become fully charged, and are consequently cut out of the circuit, the exciting circuit of a dynamo is broken, and the armature afterwards short-circuited. For a moment, then, the charging current flows through the inactive armature; but it will be seen that this has no objectionable result. The switches which control the exciting and armature circuits of each dynamo are ranged side by side; and a star wheel placed between them prevents the possibility of the armature being short-circuited before the exciting current has been broken, or the exciting current being put on before the armature has been thrown into the charging circuit.

In order to avoid a back current flowing from the batteries through the armatures of the charging machines consequent on any mistake on the part of the attendant, or a mishap, such as the sudden stoppage of the exciting current, a gravity switch, which breaks circuit if the current falls below a minimum value, is inserted in each of the charging leads; and to avoid disastrous consequences, should these fail to act in event of a sudden reversal of the current, a safety device is introduced (Fig. 1). It consists of a magnetic cut-out, set to act at 80 amperes, which is connected in the charging circuit; a fuse wire, which supports the heavy copper switch bar, is connected in parallel circuit with the magnetic cut-out. If the current rises above 80 amperes, the cut-out operates, leaving the fuse wire in circuit; this is immediately melted, in consequence of which the heavy copper switch bar falls, breaking both charging and exciter circuits.

The four sub-stations now in operation are situated at Draycott-place, Clabon-mews, Egerton-mews, and Pavilion-road. The last-named is just being started. Each sub-station contains 454 E.P.S. cells of the size known as 31L, *i.e.*, 440 for supplying the lamps and 14 back E.M.F. cells. Each cell stands on a separate wood tray, which again rests on oil insulators. A light traveller is fitted up in each battery room, with the help of which any of the cells can be removed for inspection or repair. The Clabon-mews sub-station consists of two battery rooms, 13ft. 6in. by 10ft. 4in. and 30f . by 9ft., and the cells are arranged five tiers high on the walls and on a central framework. The switch-room, which contains all the automatic transposing and regulating apparatus, is 8ft. 4in. by 8ft. Each battery-room is ventilated by a Blackman air propeller, coupled direct to a motor, which is placed in an opening made in the wall. The switch-room of a sub-station contains a number of automatic appliances, which, though appearing at first sight to form a very complex arrangement, becomes quite clear and simple when the function of each piece of apparatus and its relation to the whole is understood.

Upon commencing the day's charging the attendant at the generating station turns on a small switch for each sub-station, after which he switches the charging dynamos into circuit. Each small switch controls a relay at the sub-station connected with the operating magnet of a large transposing switch (Fig. 2) which is provided for each half battery. The function of the transposing switch is to connect the cells of the

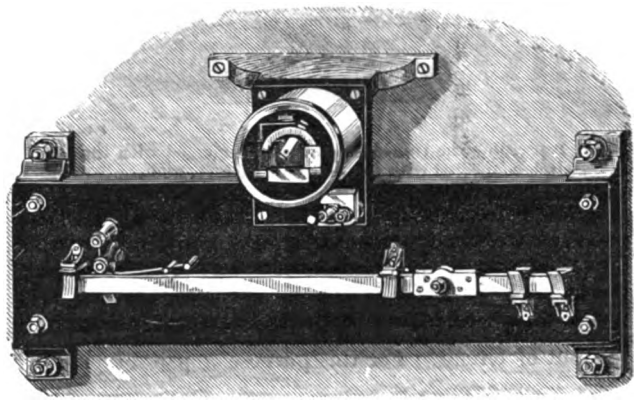

Fig. 1.—Safety Cut-out.

half battery either in series and to the charging main, or in parallel and to the distributing feeders, which it does by means of a number of contacts which are mounted on a rocking framework. When the rocking frame is down on one side, the set of contacts on that side dip into the set of mercury cups and connect the battery in series for charging; and when it is down on the other side the other set of contacts dip into the other set of mercury cups, and connect the battery in parallel for discharging. Suppose, then, that the attendant at the generating station has turned on the switch which sets the automatic apparatus in operation, the transposing switch of the first half battery is thereby thrown over from discharging to charging side, and the charging proceeds. In order to automatically cut the battery out of the charging circuit as soon as it is fully charged, a single negative plate in the half battery is selected, and a cap is arranged to catch the gas given off by the plate. The gas is led through a bubbling bottle into a small gasometer, which is adjusted so as to make a contact when the cells are properly charged, which operates a magnet on the transposing switch, causing it to rock over, and connect the cells in parallel on to the distributing feeders. The movement of this transposing switch makes a contact which causes the transposing switch of the second half-battery to rock over from the discharging to the charging position, and the charging goes on until the gasometer, which in the meantime has been emptied by an electrically operated valve, has again risen high enough to make contact, when the second half battery is disconnected from the charging mains and thrown on to the distributing feeders parallel with the

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first half. To prevent the charging circuit being broken a carbon resistance is automatically connected across the terminals of the charging mains before the charged half of the battery is disconnected, and remains connected until the second half of the battery is connected in for charging.

carrying four contacts. When the E.M.F. is normal the cross arm remains in a central position between four other contacts. If the cross arm is pushed upwards consequent on an increase in the E.M.F., the top contacts on the cross arm close a relay circuit, which operates a step by-step device (Fig. 4), which at each

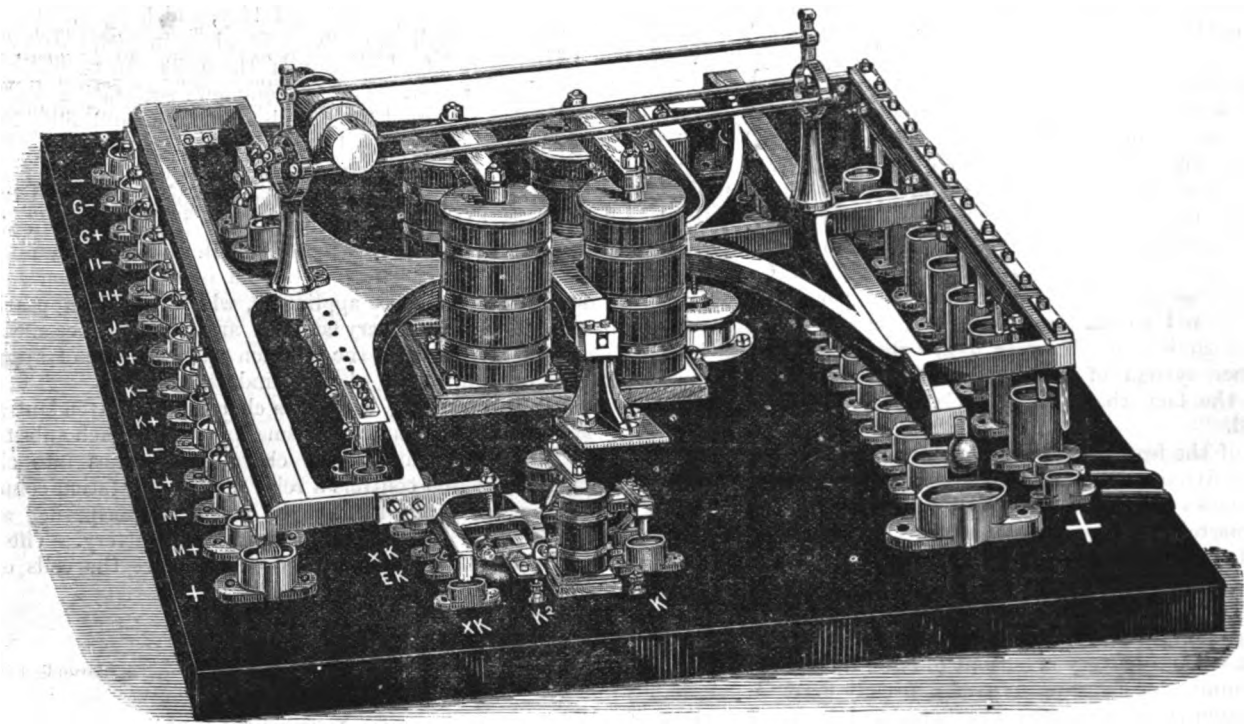

FIG. 2.—Transposing Switch.

This figure represents the transposing switch connected with the second half of a sub station battery. The small relay is actuated by the transposing switch connected with the first half battery, and controls the main magnet, which pulls the rocking frame over to the "charging" side.

The regulation of the E.M.F. delivered to the distributing feeders is performed as follows by means of counter E.M.F. cells. By this arrangement the whole of the cells are uniformly discharged, a condition essential to the maintenance of the battery in good order. These regulating cells are automatically switched in and out of circuit. For this purpose a pair of pilot wires

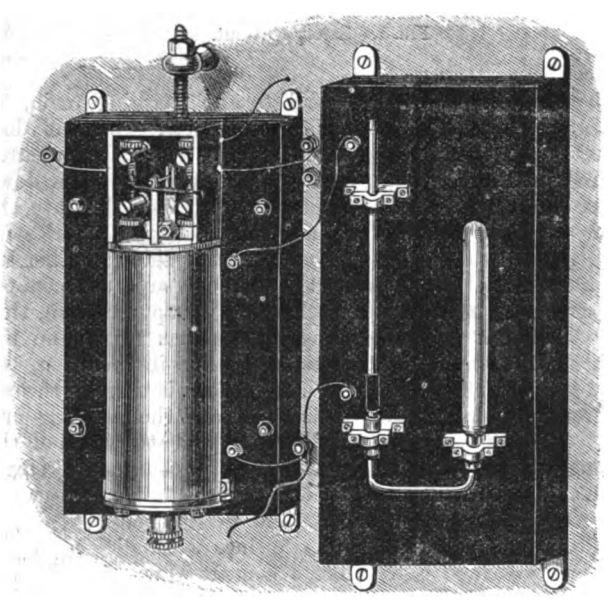

FIG. 3.—E.M.F. Governor.

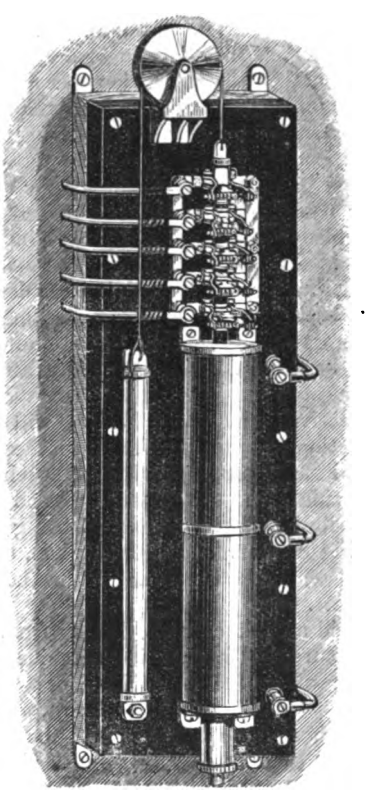

FIG. 4.—Step-by-step Device connected with E.M.F. Governor.

are brought from the point on the network where it is desired to maintain a constant E.M F. These pilot wires are connected at the substation to the terminals of a governor (Fig. 3), which consists of a high resistance solenoid—ingeniously compensated for temperature variations—with a balanced core, to the top of which is attached a cross arm,

step causes a back E.M.F. cell to be introduced into the circuit, through the intervention of the mercury switch (Fig. 4A).

When a sufficient number of cells has been introduced the core moves down, breaking the contact, and the action ceases. Similarly, if the E.M.F. on the network falls, the core of the governor descends, the cross arm makes another pair of

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contacts, and the reverse action of cutting out back E.M.F. cells takes place. The solenoid of the governor, through which the current from the pilot wires passes, is compensated against the effect of the surrounding temperature, which would otherwise cause considerable variation in the voltage maintained on the network. Instead of both ends of the operating solenoid being connected directly to the pilot wires, one end is connected through a carbon rod about $\frac{1}{32}$nd inch diameter, which introduces resistance. This carbon rod passes down the centre of a small glass tube, which is partly filled with mercury. The mercury is in connection with a closed chamber filled with alcohol, the expansion and contraction of which when the temperature of the room varies causes the mercury to rise or fall in the tube and to short-circuit more or less of the carbon rod.

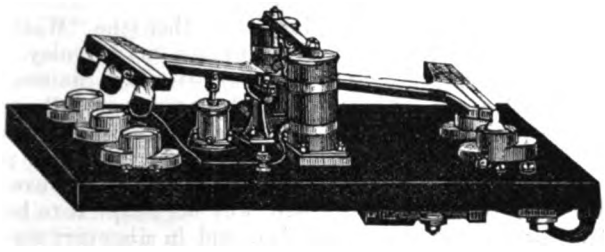


FIG. 4A.—Mercury Switch connected with the Step-by-step Device.

This device is adjusted to keep the total resistance always the same, and thus compensate for variations of temperature.

If the difference between the currents delivered by the two halves of the battery exceeds 10 per cent. of the whole, back

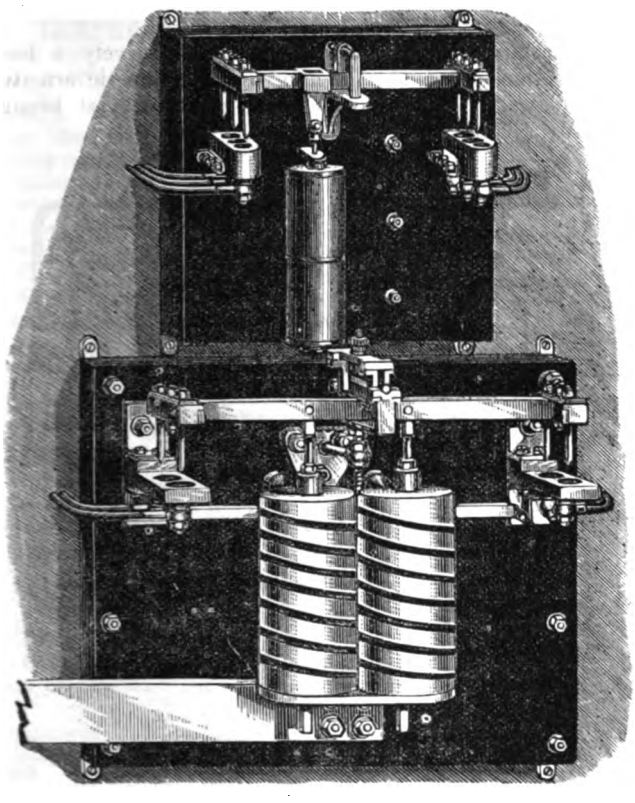
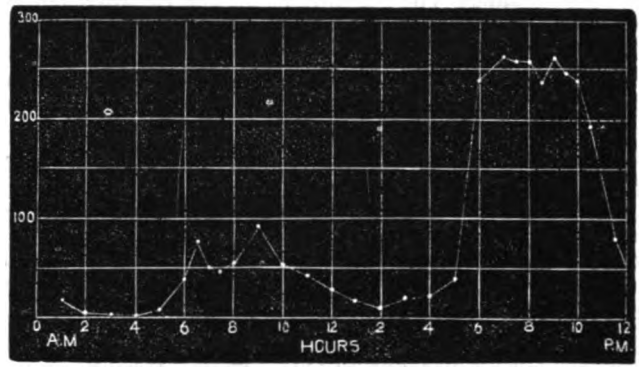


FIG. 5.—Current Regulator and Relay. The relay here shown is the one actuated either by the current regulator or the E.M.F. governor, as the case may be, and sends the currents which actuate the step-by-step device (Fig. 4)

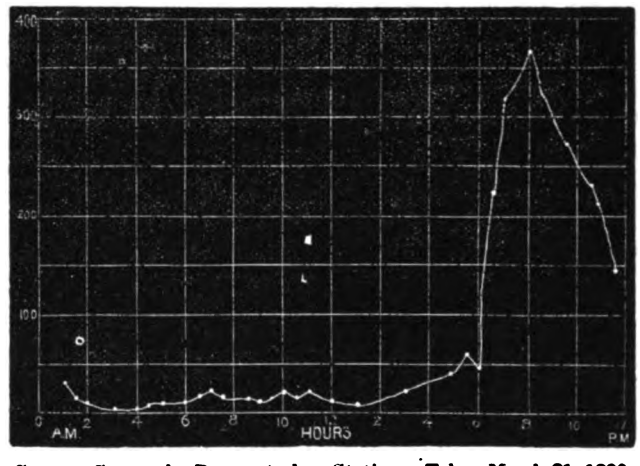
E.M.F. cells are introduced into one-half, or cut out of the other through the intervention of the current regulator (Fig. 5), which consists of two solenoids formed by cutting a spiral out of a piece of copper tube. The spirals are placed side by side, and the current from each half of the battery passes through them. The solenoids pull down either one side or the other of a balanced contact arm, which causes, through the medium of the relay (Fig. 5) and the step-by-step device (Fig. 4), a back E.M.F. cell to be switched out of the half-battery which is not supplying its share of current.

A large main switch and ammeter for the discharge circuit and an ammeter for the charging circuit is provided, and also a smaller ammeter having flexible leads and a wedge contact, which when forced between the proper contact plates diverts the current from any group of 55 cells through the ammeter, so that the current delivered by each group can be measured at will. Nothing can be easier than to keep a perfectly safe insulation between the charging circuit and the distributing network now—a good stretch of enamelled slate separating the contacts in the switch-room. We would suggest that every possible precaution should be taken to prevent this satisfactory state of things being impaired by the introduction of the continuous-current transformers.



Current Curve, the Clabon-mews Station. Taken March 4, 1890.

The present capacity of the station and sub-stations is about 10,000 lights; but the ultimate capacity, reckoning the continuous-current transformers, will reach 30,000 8—10 candle-power lamps. The Company find that 8—10 candle-power lamps give very satisfactory lighting, and that if 16 candle-power lamps are put in, the customer complains of the bill at the end of the quarter. The houses supplied by the Chelsea Company average about 100 lights (wired), in each of which the average maximum number burning at one time is about 35. Thus, each sub-station is able to supply about 70 houses.



Current Curve, the Draycott place Station. Taken March 21, 1890.

Taking the number of houses likely to take the light as about 1 in 4 (which is quite high enough), the ultimate number of sub-stations being 10, we get $70 \times 4 \times 10 = 2{,}800$ houses, which gives a rough idea of the area over which the Chelsea Company's supply from Draycott-place will extend. The charge is made by meter—the Aron being generally employed. The price charged is 8d. per unit, though the Company are empowered by their Act to charge 10d. per unit. A charge of 5s., 7s. 6d., or 10s. per quarter, according to size, is made for rent of meter.

The mains are laid underground on the Callender-Webber system, which has gained great favour with the Company's

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engineers. Their experience shows that when a separate channel is provided for each cable, as is the case in this system, long lengths of heavy cable can easily be drawn in or out. A 91/12 cable, 2in. in external diameter, 400 yards long, was recently drawn into a channel 2⅜in. diameter without difficulty, the cable being drawn 200 yards each way from a central opening. Thirteen men were employed in pulling the cable in. If a separate iron pipe were employed for each cable the cost would be too great; and experience has shown that even if a large pipe is used the cables drag very heavily one on another if several are drawn into the same pipe. As regards the relative values of rubber or gutta percha and bitumen, it is believed that the superiority of the former is seldom utilised to the full, as underground cables fail either through mechanical damage or the attacks of deleterious gases or liquids, to which rubber and gutta percha are equally as susceptible as bitumen. The charging mains (19/14) are about two miles in length, and the charging E.M F. reaches 2,200 volts.

The boilers are of the Babcock and Wilcox type of 100 horse-power nominal. There are two of these already fixed, and space is provided in the boiler-house for two more. The feed-water is supplied by a Worthington pump, and, in addition, injectors are fitted to each boiler in case of the pump failing from any cause.

The coal bunkers are situated opposite the boilers, and extend under the roadway, so that the coal is dumped where it is wanted in the first instance. The coal storage capacity is equal to about 80 hours consumption.

We give on the preceding page some supply curves taken from two of the sub-stations, a glance at which will show that the current consumed during the daytime—though it would result in a loss if it necessitated constant running of plant—yet bears no mean proportion to the whole supply, and might make all the difference between a good dividend and none at all.

THE THAMES ELECTRIC LAUNCH FLEET.

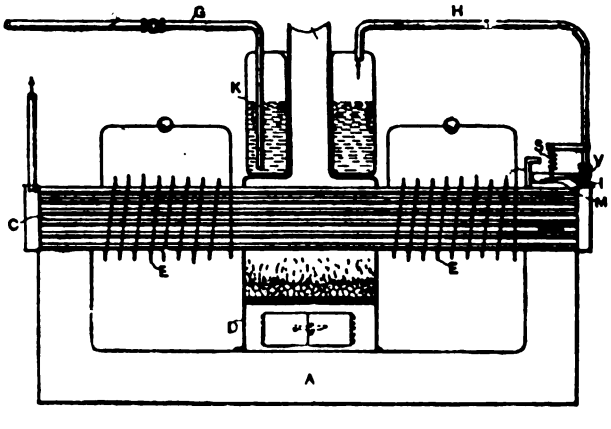
The small fleet of electric launches which figured so prominently on the Thames last season will, this year, receive several additions. Hitherto the number of this new type of river boat on the Thames has been about fourteen; this year there are to be two or three-and-twenty. Of the existing fleet far away the finest is the "Viscountess Bury," owned by Messrs. Immisch. Since she was first brought into prominence some important improvements have been made in this vessel. The first alteration was the addition of a certain amount of "dead-wood" under the stern to assist the steering properties of the launch. She also possesses now a greater length of saloon, and, by sundry other internal rearrangements, her saloon accommodation has been materially enlarged and improved. Over all she measures 70ft. by 10ft., and 60 or 70 people can be comfortably carried. She is now worked by a single motor and one 19in. propeller. When prepared for a trip she is fitted with 164 storage cells. The motor takes on the average 45 amperes and 164 volts. She is steered from the bow end of the upper deck, and, as a rule, runs at about seven miles an hour. The saloon is, of course, amply furnished with glow-lamps, and electric side-lights are provided. The "Ray Mead" is almost twin with the "Viscountess Bury," but is somewhat wider and shorter. The remainder of the present fleet,—all owned by and electrically fitted by Messrs. Immisch (or by the syndicate of which they are the visible embodiment)—are much smaller than these two. They average in length from 30ft. to 40ft., are worked by single motors with 17½in. propellers, and are provided with from 30 to 40 storage cells, giving an average current of 27 amperes. They are furnished with such electric lamps as may be necessary, but they are all open boats. Their travelling capacity is, however, pretty much the same as that of the larger launches, and they are much in favour for daylight trips.

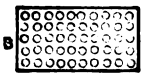
The new electric launches that are at present building for the Thames number something like eight. They are almost entirely for private owners, and will in all essential features resemble the smaller boats last described. They will probably be more luxuriously fitted, though they will not otherwise show an advance on the existing launches, but, as the electrical plant will come from the same source they will be equal in that respect. In addition to these new craft there is a small flat-bottomed electric launch being built at Hammersmith for Baron de Rothschild for use on the Dutch canals and on private waters.

Anyone who has travelled on or watched an electric launch gliding through the water can well appreciate the smoothness and quietness of its motion as compared with that of the puffing and rattling of the majority of steam launches, and of the malodorous naphtha launch. With respect to charging stations on the river there is little new to be said. It was expected that some additional shore stations would be erected, but the only one at present finished is that on Platt's Eyot; three others will be shortly equipped. Of the two largest floating stations, one is already at Maidenhead, the other (the "Watt") is now at the Eyot, but later on she will move up to Henley. The rest are, or will be, moored at Reading, Windsor, Staines, and other suitable spots. Kingston is perhaps too near to Hampton for the purpose, but it is suggested that a charging station might very well be moored at that busy and important boating place as a starting point. Seeing how well electricity has answered for launches, the question is raised, why not adapt it to house-boats, which are growing in numbers and in size every season? An electrical plant would be an immense advantage to these floating dwellings, and there would be much saving of steam and horse traction. It only remains for some ingenious mind to make the first experiment and show the way.

THE TESLA THERMO-MAGNETIC GENERATOR.

The accompanying engravings show respectively a longitudinal section and a cross section of the magnetic armature core employed in a thermo-magnetic generator just brought out by Mr. Nikola Tesla.





The Tesla Thermo-Magnetic Generator.

The generator, says the *Electrical Engineer* of New York, from which we take the account, is provided with a magnetised core or permanent magnet, A, the poles of which are bridged by an armature core composed of a shell B, enclosing a number of hollow iron tubes, C. Around this core are wound the conductors E E, forming the coils in which the currents are developed. D is a closed fire-box, and above the fire is a boiler, K, containing water. The latter is supplied by means of the pipe G, and the steam exhaust pipe H communicates with all the tubes C in the armature, so that steam escaping from the boiler will pass through these tubes. In the steam exhaust pipes is a valve, V, to which is connected the lever I, by the movement of which the valve is opened or closed. The lever

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carries an armature, M, and is held up in position to close the valve V by means of a spring, S.

In its normal condition, the armature B is magnetic along its entire length, and closes the magnetic circuit of the magnet A. Very little external magnetism is therefore exhibited, and the attraction upon the armature M is insufficient to draw it down against the force of the spring S. The steam exhaust, in consequence, remains closed. When the temperature of the central part of core B has been raised to about from 900° to 1,000° C., the magnetic circuit of magnet A is broken, and, in consequence, the external magnetism of core B greatly increased. This attracts the armature M, and allows steam to pass through the tubes C of the core. This lowers the temperature of the surface of the tubes at once, and restores, to a corresponding degree, their magnetic condition, whereupon the armature M is retracted and the steam cut off. This operation is continued, effecting a successive heating and cooling of the core, with the result of making and breaking the magnetic circuit. This entails a corresponding movement of the magnetic lines with reference to the coils E E, in consequence of which currents are developed in them.

It will be noted that by the construction adopted the source of heat is enclosed and the portions of the iron which are heated are not exposed to the air. The armature which closes the magnetic circuit is made of very thin tubes, and by this means an enormous cooling surface can be obtained. Steam is used for cooling in preference to air, partly because it is easier obtainable under pressure than air, and again, because it is more effective in consequence of its partial dissociation for which a large amount of heat is required.

THE TEMPERATURE-COEFFICIENT OF THE SWAN LAMP.*

There have been up to the present but few experiments concerning the temperature-coefficients of incandescent lamps. The following results will, therefore, be of some interest.

In order to measure the resistances of lamps at widely different temperatures, a bath of linseed oil was employed. The lamp to be tested was fastened to a stirrer (to which either a to-and-fro or up-and-down motion could be imparted) inside a glass bowl filled with oil. This bowl was suspended inside an enamelled saucepan filled with oil, and was also furnished with a stirrer. As soon as the oil reached the boiling point the saucepan was placed in a box of sawdust, and the resistance measured from time to time whilst the cooling took place. A nitrogen thermometer was used to take the temperature of incandescence of the lamp. The establishment of a contact between the lamp and the wires connected with the measuring apparatus presented considerable difficulties. As tin fuses at the temperatures employed, it was only possible to make use of lamps provided with platinum hooks. The contact of the latter with the copper wires was secured by means of an electrolytic deposition of copper.

The measurements were also somewhat difficult to effect, for the resistance of the lamp was not constant. This was caused by the heating of the filaments by the measuring current, although the latter was due to one Leclanché cell, and was, therefore, very feeble. This difficulty was overcome by inserting a high resistance in the battery circuit. The results thus obtained are given in the following tables :—

I.

Temperature of the lamp.	Resistance in ohms.	Temperature of the lamp.	Resistance in ohms.
300	51·003	175	54·982
273	51·826	137·5	56·174
245	52·688	22·5	59·492
209	53·834	20·0	59·560

II.

286·2	100·1	114·5	125·34
284·5	100·19	113	125·54
282	100·6	112	125·75
254	104·7	70·2	131·85
251·5	105·05	68·6	132·05
250·5	105·15	68	135·25
210	111·15	47·5	135·25
209	111·35	46	139·14
208·5	111·4	20·6	139·24
165	117·8	20·1	139·34
164	117·94	19·6	—
163	114·4		

* From *La Lumière Électrique*.

On plotting these results on squared paper it is found that they are fairly accurately represented by the formula

$$y = a + b\,x.$$

The temperature coefficient corresponding to the resistance at 20 deg. is

0·000513 for I.

and

0·001056 for II.

The two lamps were apparently of English manufacture.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, May 30th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "Astronomical Telescopes." By A. A. COMMON, F.R.S.

SATURDAY, MAY 31st.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Ballad Music of the West of England." By the Rev. S. BARING-GOULD, M.A.

5 p.m. General Monthly Meeting.

MONDAY, June 2nd.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting. Paper to be read: "Pick's System of Manufacturing Salt in Vacuo." By PERRY F. NURSEY.

TUESDAY, June 3rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Natural History of Society." By ANDREW LANG.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Annual General Meeting.

THURSDAY, June 5th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Flame and Explosives." By Prof. DEWAR, F.R.S.

CHEMICAL SOCIETY.

8 p.m. "Note on the Preparation of Pure Crystalline Copper." By C. C. DUNCAN.

FRIDAY, June 6th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1). "The Effect of Change of Temperature on the Villari Critical Point of Iron." By HERBERT TOMLINSON, F.R.S. (2). "The Diurnal Variation of the Magnet at Kew." By W. G. ROBSON and S. W. J. SMITH.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Search for Coal in the South of England." By Prof. W. BOYD DAWKINS, F.R.S.

SATURDAY, June 7th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Ballad Music of the West of England." By the Rev. S. BARING-GOULD, M.A.

*** **Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.**

A Dynamo Telegraph Plant.—The dynamo plant of the Western Union Company, at Albany, N.Y., which has been in operation since July, 1889, displacing 7,000 Calland cells, has, says the *Electrical World*, greatly improved the service. The plant, which is located in the Edison Light Station, two blocks distant from the telegraph office, consists of nine Edison dynamos. Three potentials, 90, 150, and 250 volts, are found to be sufficient for all the service. Artificial resistance is added to the city wires and loops and other short wires, so that the 90-volt current can be used with perfect success. The currents are carried to the telegraph office in an aerial cable. There is also a spare cable between the station and the office on an entirely different route. An independent plant has been installed at an intermediate point on the route of the spare cable, for use in case of serious accident or interruption at the regular station. The independent plant consists of two dynamos, generating current at a potential of 250 volts. This is used to replace the highest potential sent out from the regular station, and supplies the quadruplexes. By means of rheostats, this current is cut down to meet the requirements of the other circuits.

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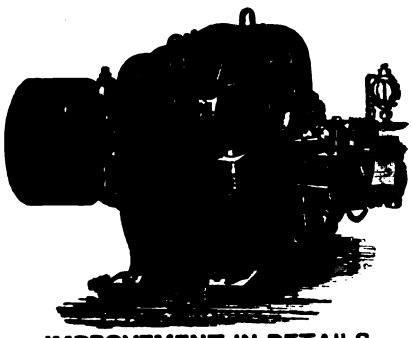

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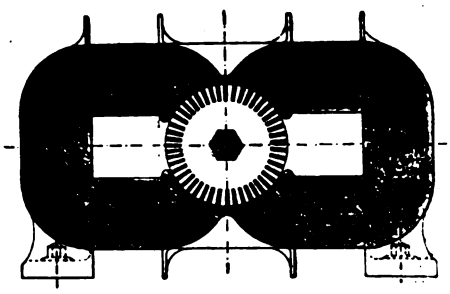

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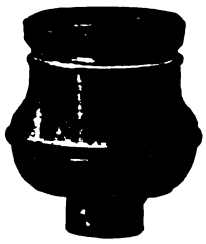

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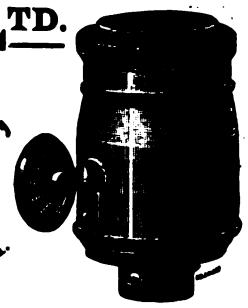

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Gülcher Elec. Light & Power Co. 6
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Laing, Wharton and Down (Thomson-Houston) 9, 19
Parsons (C. A.) and Co. ..... —
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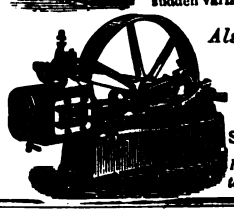
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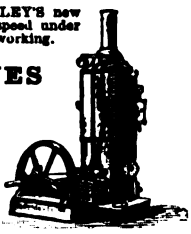

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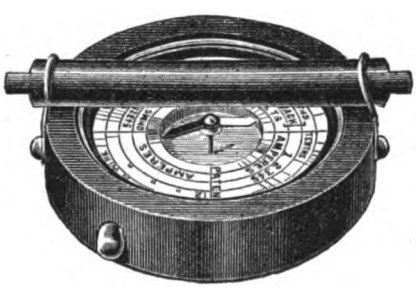

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was a united action on the part of the two bodies to secure a highly influential and representative deputation to the Board of Trade, at which Sir William Thomson, as President of the Institution, Lord Rayleigh, Mr. Crompton and others, laid before the President of the Board of Trade the imperative reasons for taking action in this matter.

It is gratifying, therefore, to all who recognised for the last five years the desirability of this Laboratory to find that Major Cardew is able to speak of this Standardising Laboratory as on the way to become an accomplished fact; and that, to quote his own words, "the Board of Trade have undertaken to provide something in the nature of a testing establishment for instruments intended for the measurement of electrical quantities, and that they have taken powers under the Weights and Measures Act of last Session to undertake such testing and verification and to charge fees for it; so that these verifications, whatever their scientific value, will possess a legal value." It will be seen from this and from the remarks which follow in Major Cardew's Paper that the outlines of the new Laboratory are being drawn in a modest and unpretentious manner; and that the electrical standardising operations are to commence on a scale which, while allowing them opportunity to justify the expectations of their advocates, at least in parts, will deal gently with the feelings of the taxpayer and not give occasion for anxiety to my Lords of the Treasury.

We have no fear, however, that the utility of the Laboratory will not amply justify the establishment of it. Our French and German neighbours have started more ambitious undertakings; and by the side of the Laboratory in the Place St. Charles the scheme outlined to us the other evening has, perhaps, a somewhat one-horse aspect. There are excellent reasons, however, for pitching the note low at the initiation of a scheme such as this; and not the least of these is that it is to such restraint that we are indebted chiefly for the fact that it is realised at all. As the Laboratory proves itself able to meet a definite want, it will certainly be extended. There are two or three conditions, however, which will determine that rate of growth. It is essential, in the first place, that it should be adequately provided with instrumental appliances for doing with the highest degree of perfection that which it undertakes to do. There ought to be no cheeseparing policy in the first outlay for the outfit of the Laboratory. Major Cardew tells us that the first operations will be a series of redeterminations of the practical units. He does not say whether these redeterminations will be made at the Standardising Laboratory itself, or whether the resources of other institutions will be laid under contribution. Considering the experimental difficulties, and the vast labour attending such redetermination, we can hardly suppose that he contemplates a redetermination *ab initio* of the ohm, the electro-chemical equivalent of silver and the specific resistance of mercury. He tells us that the Board of Trade are not bound to the so-called legal ohm. If, however, there is to be another change, it is devoutly to be hoped that it will be a final one, and that it will be taken with sufficient consensus of opinion to make it so. We are now in possession of a British Association ohm and a Paris Congress ohm; if we add to this a Board of Trade ohm, let us at least hope that this last will be a sufficiently approximate realization in the flesh of the ideal 10^9 centimetres per second, not to require touching up again at least during this century. For practical people the question that overshadows all others is the permanence of the standards. Whatever is selected must be adhered to, otherwise cargoes of instruments will continually be relegated to that category in which they are spoken of slightingly as "our old pattern." Another matter of supreme importance will be the selection of observers of trained accuracy, who will be the actual persons engaged in making the comparisons. We feel sure that with Major Cardew's scientific and practical training, aided, if need be, by consultation with others, the methods finally adopted will be the best, and the standards of comparison be prepared and maintained with the greatest care. When all this is said and done, there still remains the actual comparison of the submitted instrument to be made with the authoritative standard; and the value of the certificate will entirely depend on the care with which this is done. We hope that neither in men nor in materials will the new Laboratory start insufficiently equipped, and that entire confidence will be widely diffused in its accuracy from the very first.

The remarks which Major Cardew makes as to the limits of the accuracy aimed at are dictated by sound common sense. It is much easier to talk about one-tenth per cent. error in an electrical instrument than to detect it, far less to remain within that limit. An accuracy of a quarter per cent. will be quite sufficient for practical purposes if that range of comparison is maintained. A great part of the work of that Laboratory will probably be in checking and certifying the sub-standards to be employed by the "electrical inspector" of the future. As Major Cardew says, the appearance of this new functionary will be like the dawn of a fresh species; and it is to be hoped that no pains will be spared in providing him with his weapons of offence and defence. In some far distant time the fossil remains of an electrical inspector will no doubt be exhumed by future archæologists, accompanied by the fragments of something which experts of the twenty-first century will oracularly pronounce to have been one of those rudimentary forms of voltmeter employed towards the end of the nineteenth. An electrical Owen of future days will "restore" the outlines of this instrument from some element, perhaps still retaining a trace of the Board of Trade stamp. To maintain a practical uniformity amongst these instruments of inspection, and to check such sub-standards as are sent in by makers, as well as the electric supply meters which may be required as standards, will keep the new Laboratory busy for some time to come. We venture to prophesy for it a career of great usefulness; and in another five years we may, perhaps, look for a Paper from Major Cardew, to be read before the Institution, describing its operations when in full swing, thus completing a trio in which its inception, its inauguration, and its completion are described.

ELECTRIC RAILWAY POWER TESTS.*

BY IRVING HALE.

The following tests were made last February on the South Broadway Electric Road (Sprague system), Denver, Colo., with a view to determining the amount of power required at various speeds and under various conditions, the various causes of waste of power, and the remedies for these losses. More particularly it was desired to establish the correctness or incorrectness of two theories that seemed justified by abstract considerations:—First: That it is economical to run at as high speeds as practicable. Second: That power will be saved by using one motor instead of two whenever conditions allow.

The tests in Denver were made as follows:—The power plant consists of a 60 horse-power Armington and Sims engine, running a 40,000 watts Edison dynamo.

The car tests were made at night, when no cars except those experimented on were running. In each test the car was run in both directions over one-tenth mile of almost level track, and a mean of the two results taken. On the car the time was taken; at the stations the ammeter was read, the potential being accurately maintained at 500 volts. The total resistance of the circuit was mea-

* From the *Electrical World*.

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sured with car at middle of the one-tenth mile, the wire from trolley being connected to ground wire in car, thus including all resistances that might exist in the trolley, track-frame and wheel contact with rails. From this resistance and the current readings the loss in line was computed, and was deducted from power at station to give power at car. The car was first run over the course both ways with the controlling switch successively in each of the different positions, both motors being in use. The same runs were then made with one motor cut out but turning, the raw-hide pinion being left on. The pinion was then removed and the same tests repeated. On another occasion runs were made first with one motor cut out, but with its brushes in, and then with the brushes removed, the idea being to detect any possible loss in the way of local current, friction, &c., due to pressure of brushes. There was no appreciable difference above what might be due to errors in observation.

The power actually required to run the car at various speeds was approximately determined by two methods, as follows: Another car was run over the course in both directions at different speeds and readings taken. This car then hauled, at about the same speeds, the car on which tests were to be made. The two power curves being plotted, the difference in their ordinates at various abscissæ (representing speeds) should give approximately the power required to haul the towed car at these speeds. By the other method, the car to be experimented upon was run at various speeds and timed over a measured course just before reaching the $\frac{1}{10}$ mile course, when the current was thrown off and the car allowed to run until brought to rest by the resistance. The experiment was then repeated in the opposite direction. The energy of the car at the computed velocity being overcome in a measured distance by the car resistance plus the grade resistance when going up, and by the car resistance minus the grade resistance when going down, the coefficient of friction or resistance and the inclination of the grade could be computed without knowing the weight of the car, which appears as a factor in both members of the equations. This gives the average resistance of the car while slowing down, or approximately the resistance at one-half the maximum speed. The highest speed observed was 14·7 miles per hour, so the coefficient determined applies to speeds of 7·4 miles and under. The results of different observations by this method agree quite closely with each other, as do also the computed values of the grade. The weight of the car was not accurately known, but computing from known weight of motors and truck, and assumed weight of car body, the total weight with the occupants was about five tons. Curve A (Fig. 2) represents the power, computed on this basis, required at speeds below 7·4 miles an hour, while curve A′ shows power required at speeds between 10 and 13 miles per hour computed by the first method. These two curves, although not covering the same speeds, appear to agree quite well, and by joining them by the supposititious dotted line, a curve is obtained that corresponds quite well with the form that would be expected.

These tests for resistance, made on the same night as the speed and power tests, were not satisfactory, and another set was therefore taken on another night. To detect and allow for any difference in resistance on the two nights, due to different condition of bearings, track, &c., a set of speed and power tests was also made on the second night, and their curve plotted alongside the first night's curve. It was nearly parallel to the latter, and from ·3 to ·7 horse-power above it, the difference increasing with the speed. These corrections, subtracted from the resistances on the second night, give what would have been the resistances on the first night, and it was from the corrected values thus obtained that the curves A and A′ were plotted. If the motors and gearing were removed from the car, this curve would be considerably lower. It could approximately be determined by making the hauling test with both main gears removed, and then allowing a proper correction for weight of motors. Time did not permit this test to be made.

With the foregoing statement of methods employed, the tables and curves require little further explanation.

Station Tests.

TABLE I.

No. of test.	1 I. H.-P.	2 Net H.-P.	3 E. H.-P.	4 Electrical efficiency.	5 E. H.-P. / I. H.-P.
				per cent.	per cent.
1	9·1	0	0	—	—
2	23·8	14·7	13·4	91·2	56·3
3	32·6	23·5	22·12	94·1	67·8
4	38·3	29·2	26·81	91·8	70·0
5	51·6	42·5	36·86	86·7	71·4

Car Resistance.—First Method.

This method has previously been explained. The results are shown in Fig. 1.

Second Method.

TABLE II.

Direction.	Speed in ft. per sec. just before breaking current.	Distance run after breaking current before stopping.	Coefficient of resistance.	Grade computed.
South.....	15·4	342ft.	·0089	·00179
North.....	16·5	594ft.		
South.....	17·9	508ft.	·0079	·00194
North.....	18·2	870ft.		
South.....	21·1	685ft.	·0082	·00187
North.....	22·2	1,199ft.		
Mean	.....	.....	·0083	·00187

Lbs. per ton, 16·6.

Assuming weight of car and occupants as five tons, curve *A*, Fig. 2, was computed and plotted.

TABLE III.

	Position of car switch.	Miles per hour.	E.H.P. at station	E.H.P. at car.	H.P. hours per car mile.	E.M.F. at car.	Counter E.M.F.	Electrical efficiency $\frac{e}{E}$ per cent.
Both motors.	1	11·43	6·37	6·22	·54	488·3	450·5	92·3
	3	13·6	7·87	7·64	·56	485·6	450·3	92·7
	4	14·1	7·71	7·49	·53	485·9	461·4	94·9
	6	16·0	10·40	10·00	·63	480·9	460·9	95·8
	7	17·6	10·56	10·15	·58	480·6	464·7	96·7
One motor in use. Other motor cut out, but geared.....	1	9·5	4·36	4·29	·45	492·0	440·5	89·5
	3	9·7	5·20	5·10	·53	490·5	446·5	90·6
	4	10·9	5·03	4·94	·45	490·8	458·8	93·5
	6	13·7	6·37	6·22	·45	488·3	463·8	94·9
	7	14·5	6·54	6·38	·44	488·0	468·3	96·0
One motor in use. Other cut out, & ungeared..	1	10·0	2·86	2·83	·28	494·8	461·2	93·2
	4	12·0	3·69	3·64	·30	493·2	469·8	95·0
	7	15·0	5·20	5·10	·34	490·5	474·8	97·0

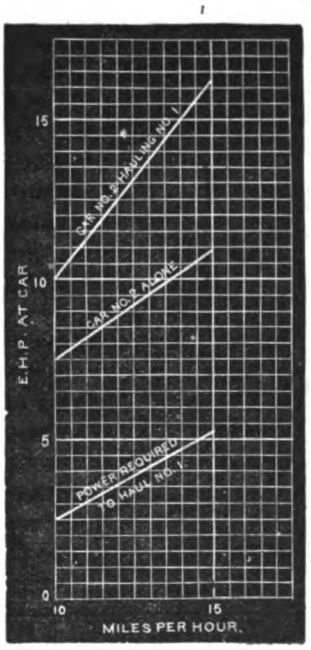

FIG. 1.—Power required by cars.

Figs. 2 and 3 are plotted from Table III. The curve A A′ is obtained as explained above, and is to be considered in connection with curve D. The actual power required to haul car with one motor ungeared should have been obtained in the same manner; but as this was not done, the hypothetical curve *a′* was constructed by subtracting from the ordinates of A′ the corresponding difference between ordinates of B and C, which ought to represent power saved by ungearing one motor. Fig. 3, plotted from Column 5 of Table III., requires no explanation.

Figs. 4 and 5 result from a combination of the preceding figures. Fig. 4 represents a supposititious case of road equipped, like this road, with a 60 horse-power engine and a 53 horse-power dynamo, operating four cars with two motors each, and shows the conditions at different speeds, all four cars running at same speed. Fig. 5

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shows the same plant operating eight cars with one motor each, which will require about the same maximum power.

Discussion of Curves and Tables.

Figs. 2 and 3 show the decided saving in power effected by cutting out one motor, especially if its pinion be removed. Fig. 3 shows that the horse-power hours or power consumed per mile run varies but little with the speed. Consequently, by running at high speeds, a given number of miles will be covered in a day with about the same expenditure of coal, and with fewer cars, drivers and conductors, thus reducing cost of equipment, interest on investment, and wages of attendants, while the public will get faster transit.

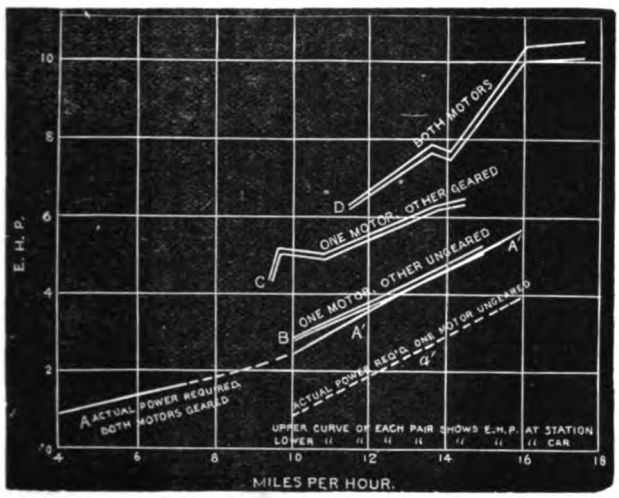
E. H. P.
MILES PER HOUR.
BOTH MOTORS
ONE MOTOR, OTHER GEARED
ONE MOTOR, OTHER UNGEARED
ACTUAL POWER REQ'D. ONE MOTOR UNGEARED
A ACTUAL POWER REQUIRED, BOTH MOTORS GEARED
UPPER CURVE OF EACH PAIR SHOWS E.H.P. AT STATION
LOWER " " " " " " " CAR

Fig. 2.—Relation between power and speed.

General conclusions can best be drawn from Figs. 4 and 5, which show graphically the causes and amounts of the various losses. In the first place it should be borne in mind that these curves, representing as they do a supposititious case, where all the cars are running at uniform speed, do not by any means tell the whole story. It is only necessary to stand in the station and watch the sudden variations of the ammeter and the efforts of the engine to keep a steady gait when several cars start at once, to be convinced that there should be a good margin of power allowed in the station equipment, and especially that the engine should be strongly built, heavy, and have a much larger fly-wheel than is usually provided to aid in carrying it smoothly over the rough places.

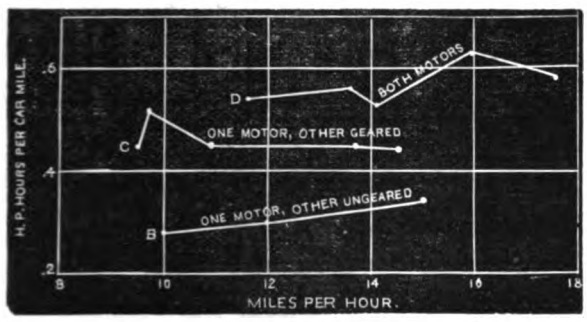

Fig. 3.—Relation of h.p. hours to speed.

In Figs. 4 and 5 the difference between curves G and E represents loss in engine and dynamo friction, which is assumed to be constant, and is about 15 per cent. of the normal power of the engine. Engine and dynamo friction were not separated in test, and curve F is constructed on the supposition that two-thirds of friction is due to engine and one-third to dynamo. The space between E and D shows electrical loss in dynamo about 9 per cent. of load. The difference between D and C represents loss in line, which in this case is very small, and in a properly designed line should not as a rule exceed 10 per cent. The difference between C and B shows electrical loss in motors. The space between B and A shows loss chargeable to friction of motor and gearing.

Remedies.—The friction of engine cannot probably be decreased very much, but as it is of much greater importance at low load than at full load, it is evidently desirable always to run as near full load as possible, consistent with a safe margin for sudden strains. On a road with varying traffic this can be accomplished only by having several dynamos and engines, running at any time only as many as are necessary to give the required power and margin. This is an argument in favour of using a number of high-speed engines coupled direct to dynamos, instead of one or two large low-speed engines with counter-shafting. The same remarks apply to loss in dynamo friction.

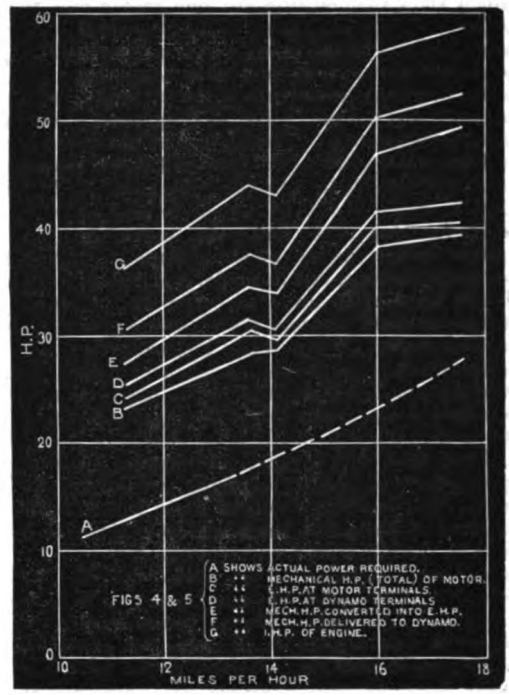
H.P.
MILES PER HOUR
A SHOWS ACTUAL POWER REQUIRED.
B " MECHANICAL H.P. (TOTAL) OF MOTOR.
C " E.H.P. AT MOTOR TERMINALS.
D " E.H.P. AT DYNAMO TERMINALS.
E " MECH. H.P. CONVERTED INTO E.H.P.
F " MECH. H.P. DELIVERED TO DYNAMO.
G " I.H.P. OF ENGINE.
FIGS 4 & 5

Fig. 4.—Diagram of Losses. Double motors. Four cars, two motors each.

The present dynamo is a very efficient machine, and no very great improvement can be looked for. The loss in line is simply a question of copper, and must be decided on the basis of waste of

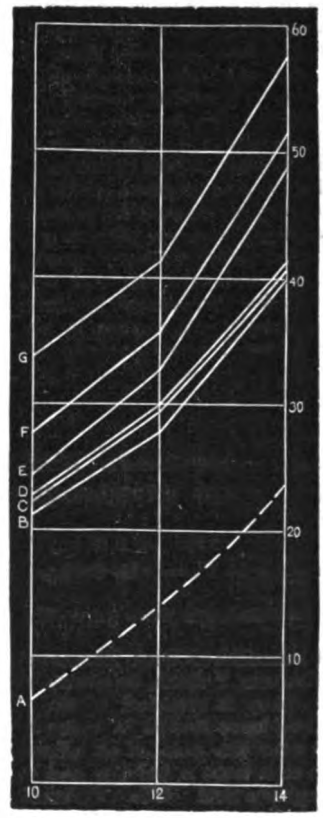

Fig. 5.—Diagram of Losses. Single motors. Eight cars, one motor each, other ungeared.

power versus interest on first cost, care being taken not to allow such a percentage of loss, even if dictated by theoretic economy, as to give unsatisfactory service at most distant parts of line. The electrical loss in motors is as small as can reasonably be expected.

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The greatest loss of all appears to be in the mechanical means employed to transmit the real power exerted by the motor to the wheel. The obvious remedy is to reduce the gearing to a minimum, and the first step is to concentrate the working force in one motor. The great saving effected by this is plainly illustrated in Figs. 2, 4, and 5, which show that cutting out one motor and removing its pinion reduces the power required nearly one-half, and that eight cars thus treated can be run at a given speed on the same indicated horse-power as four cars with both motors running.

There are, however, some arguments in favour of two motors that must not be overlooked. First—They guard against accidents. But in the present state of development of the street car motor it is believed that such accidents are not sufficiently frequent to make the game worth the candle. Second—On many roads one motor is insufficient to do the work occasionally or frequently imposed. The remedy for this is to make the motor larger. The contracted space under the car places a limit on increase in size; but considerable increase can be made, and it must be remembered that owing to the smaller *waste* of power in the single motor, it need not have as much nominal power as the two motors, in order to do the same work. If it is found impracticable to make a single motor large enough to do the work on some roads, then, in those situations, two must be used, but in many places one would suffice. Third—On very steep grades it is advantageous to have a motor on each axle, as the adhesion of all four wheels is thus utilised for traction. But there are many roads where this is unnecessary. Most roads with heavy grades requiring two motors would require only one over the greater portion of their length. This suggests the desirability of being able mechanically to throw in one or both motors at will, the idle motor being ungeared.

The conclusions suggested by the preceding tests would seem to be these:—Use high-speed engines having extra strength and weight and heavy fly wheels. Design power station so that under all conditions it may be possible to have just enough engines and dynamos running to give the required power with a safe margin. Put up a liberal system of line feeders, and be sure that in adding cars to the equipment the line loss does not become objectionably great. Run at as high speed as the law allows. If cars are equipped with two motors, run with one of them cut out and its pinion removed, provided the maximum work is within the capacity of one motor. On roads with light grades and moderate speeds and loads, equip cars with one motor, making it larger than 15 horse-power if necessary. Avoid, however, being led by these theoretical considerations into the error of providing insufficient power to meet the greatest demands that will be made upon the motors.

As to possible future developments, these observations point to the concentration of power into a single motor and set of gearing on which shall be spared neither careful workmanship, expense, nor weight necessary to make it thoroughly substantial and trustworthy; to the desirability of a simple and efficient mechanical contrivance, by which either or both of two motors (when two motors are necessary, either to give required power or utilise the adhesion of all four wheels) may be thrown in or out of gear, and lastly to the possible desirability of a motor without gearing, with armature attached direct to axle. For street-car speeds it is probable that the electric difficulties, increased size and weight of such a motor may always outweigh the gain secured by abolition of gearing; but when high speed railway trains are run by electricity, as they certainly will be before long, it is not unlikely that the advantage will be reversed.

ON PROF. ELIHU THOMSON'S ELECTRO-MAGNETIC INDUCTION EXPERIMENTS.*

By J. A. Fleming, M.A., D.Sc., M.I.E.E., Professor of Electrical Engineering in University College, London.

(Continued from page 61.)

One of the most beautiful of Prof. Thomson's experiments illustrating this repulsion can, I think, be shown to you now.

An incandescent lamp is attached to the terminals of a coil of wire, and the coil and lamp floated in water or hung from a scale beam (*see* Fig. 24) over the pole of an alternating magnet. The coil and lamp form as it were a balloon and car floating in space, and placed in a magnetic field. When that magnetic field is rapidly alternated by exciting the magnet, the induced currents created in the coil make themselves evident by illuminating the lamp, and the repulsive electro-dynamic action shows itself by lifting the lamp and coil upwards through the water or the air.

The same experiment renders it possible to show the effect of magnetic screening very prettily. If I introduce a plate of copper between the magnet pole and the induction coil attached to the lamp, the copper "screens" the coil from the inductive action of the pole, and the light of the lamp disappears. I must next direct your attention to some curious effects which are found to exist when two conducting circuits are exposed to the magnetic flux from an alternating magnetic pole, and which depend upon the interaction of the currents induced in each respectively. Prof. Thomson embodies these facts now to be considered in four laws, which may be briefly stated as follows:—

1. If two or more closed circuits are similarly affected inductively by an alternating magnetic field they will attract one another, and tend to move into parallelism.

2. Iron or steel masses placed in an alternating field give rise to shifting magnetism or lines of force moving laterally; and may, therefore, act to move closed circuits in the path of such shifting lines.

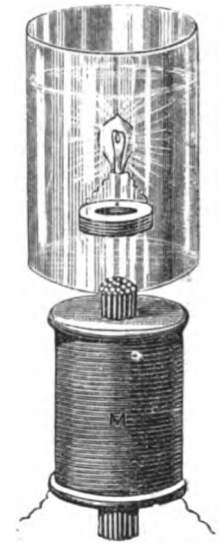

Fig. 24.

3. Closed circuits in alternating magnetic fields or fields of varying intensity give rise to shifting magnetism, or lines of force moving laterally to their own direction; and may, therefore, act to move other closed circuits in the path of such lines.

4. Iron or steel masses may, when placed in an alternating magnetic field, interact with other such masses, or with closed electric circuits, so as to produce movement of such masses or circuits relatively, or give rise to tendencies to so move, the effects depending on continual adaptations of shifting magnetism and retained magnetism relatively.

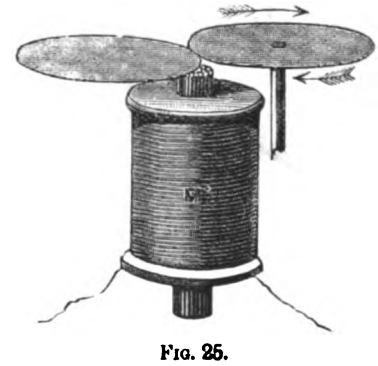

Fig. 25.

It is a simple matter to illustrate these principles; and the experiments which are designed so to do bring before us some striking peculiarities of the action of magnetic force upon closed circuits and upon masses of conducting and magnetisable matter.

Returning, first, to the simple experiment of a copper ring repelled by an alternating pole, we find that if we add a second ring under the first they both attract one another, and the two rings are supported and repelled as if they were one ring. It is obvious that at any instant the induced currents in both rings are in the same direction, and hence they attract one another.

Such an attractive action can be made to produce continuous rotation. We have only to place a copper ring or plate over the alternating-current coil or pole, and then bring a copper disc, free to revolve on pivots, into proper position relatively thereto. This can best be done by placing the ring or plate so as to be somewhat to

* A Paper read before the Society of Arts, May 14, 1890.

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one side of the pole, so as to "shade" part of it, as it were, while a part of the pivoted disc is placed under or over it, in front of the alternating pole. The disc then begins to revolve rapidly on its pivot (*see* Fig. 25). A little consideration shows that in this case the fixed copper plate shields a portion of the pivoted plate. The currents induced in the fixed plate attract the non-symmetrically placed induced currents in the other disc and set up a tangential action or couple upon it, tending to pull it round. The continual repetition of this action as each portion of the plate becomes in turn the seat of maximum inductive action, results in a continual revolution of the plate. Two pivoted discs may be used instead of one, and it will be found that they may each "shade" a portion of the pole, and, if made to overlap, they will pull each other round and revolve in opposite directions when the alternating pole acts upon them.

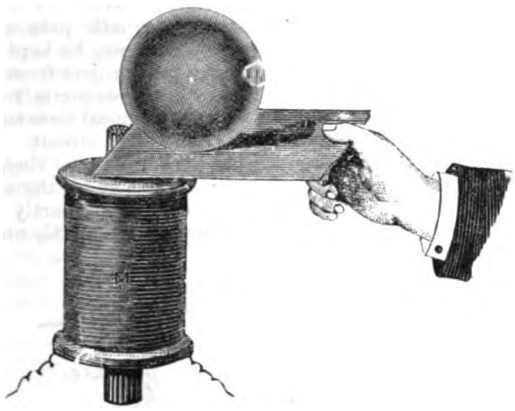

FIG. 26.

This principle of "shading" a portion of the magnetic pole, and hence causing an unsymmetrical distribution of induced currents in a conducting body capable of revolution on a pivot, has been developed by Prof. Thomson in many extraordinary ways.

Floating, for instance, a hollow sphere of copper on the surface of water in a glass vessel, he places this over an alternating magnetic pole. If the pole is placed directly under the sphere, the electro-magnetic action would, as before explained, result in a repulsive force acting upon the disc. If, however, a sheet of copper is placed half over the pole so as to "shade" a portion of the copper sphere, the currents induced in it are unsymmetrically situated with respect to its centre, and react upon the current induced in the plate. Hence, the electro-magnetic action resolves itself into

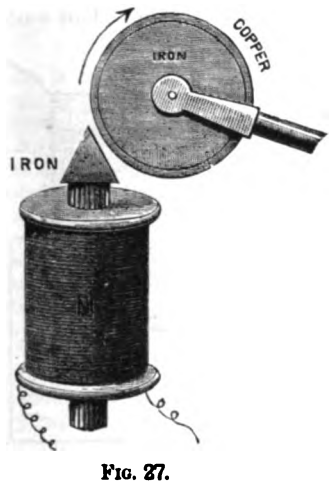

FIG. 27.

a torque or couple, causing the ball to spin rapidly upon its centre, and take up a rapid rotation. So considerable is the rotational force brought to bear that the ball will rotate when merely laid on a sheet of copper, even overcoming the friction of such rotation on its equatorial line, provided that the ball and supporting plate are so held over an alternating pole that the plate shields a portion of the sphere (*see* Fig. 26). Given this principle that by properly "shading" a pole from a portion of a solid body capable of revolution round a line or axis, it is easy to see that countless forms of electromotor can be designed.

A sort of anemometer with copper discs for cups resembling the cross of a Crookes' radiometer can be set in rapid rotation by an alternating pole, if a copper screen be placed so as to shade one side of it.

This unsymmetrical development of the induced currents can be produced by a suitable disposition of the magnetic pole alone. Thus we may place a cone or wedge of iron on the alternating pole, and hold near it a copper ring mounted so as to be able to revolve (*see* Fig. 27). The copper cylinder or wheel revolves rapidly under the action of the periodic field, and its direction of motion is such that it seems to be blown around by a blast from the end of the magnetic cone. Prof. Thomson has constructed a curious electrical gyroscope as follows: a vertical pivot projects from the centre of an alternating pole (*see* Fig. 28), upon which is pivoted a horizontal rod bearing a counterpoise, and a copper wheel preferably with an iron core attached to it, gyroscope fashion, by means of a copper frame. The copper frame is placed in an inclined position with respect to the horizontal. Under these circumstances a vigorous rotation is

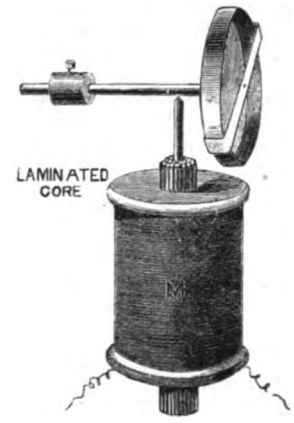

FIG. 28.

communicated to the gyroscope wheel when the alternating field acts upon it. The copper frame shields one side of the wheel more than the other, and as a result the induced currents in the copper wheel are unsymmetrically placed with respect to its axes of rotation, and it experiences a violent torque.

These experiments can, by a little ingenuity, be endlessly multiplied when once the fundamental principle is grasped. Bodies can be made to rotate and move, taking their movements from the magnetised space in which they are placed, and without being supplied with current from an external source.

Prof. Thomson has, however, studied some curious cases of magnetic motion in which rotations are obtained when iron or copper pivoted discs are placed near to iron or steel bars in which the propagation of magnetism is throttled by closed circuits. If a longitudinally laminated iron bar has a closed copper band or coil placed round it at one point, and if such a bar is made magnetic by a periodic current traversing a magnetising coil embracing another part, this structure becomes capable of rotating iron or copper discs held near it. The explanation of this effect is probably to be found in the fact that the closed embracing coil tends to throw off the magnetic lines of force laterally at that point. Consider a bar (Fig. 29) A B, in which lines of magnetic force are being established in the direction from A to B. That is to say, let magnetic induction be increasing in the bar in a direction from A to B, at C let there be a closed

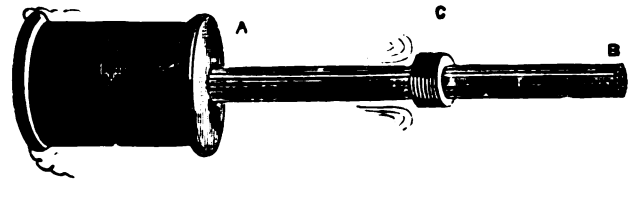

FIG. 29.

coil embracing the bar, the magnetic induction during its period of increase is setting up in this circuit an electromotive force which establishes in the circuit a current whose lines of force are opposed to the primary induction inside the coil, and therefore in the iron included in the coil, but in the same direction outside the coil, and therefore outside the iron. The result is as if the lines of primary magnetic induction in the iron were shed off laterally and escaped round the coil. When the magnetic induction in the iron, due to the magnetising coil, is made periodic, this action will create a kind of lateral pulsation of the magnetic lines of force in the neighbourhood of the closed coil. If, then, a moveable conductor is held near such a magnetically throttled bar, it will be subjected to a displacement of lines of magnetic force through it laterally, and will hence have eddy electric currents generated up

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in it. These currents, persisting into the period of reversal of the field in virtue of self-induction in the conductor, will cause the portion of the conductor in which they are set up to be continuously repelled, and hence to take up a motion of rotation. A ring of cast-iron having a closed coil wound on it at one point, is held so that another point on its circumference 90deg. removed from the closed coil, is on the pole of an alternating magnet. An iron disc centrally pivoted and held concentric with the ring, is rotated when the magnet is energised by an alternating current. It is not even necessary to have a closed coil on one part of the active magnetic bar, provided that this bar is not laminated, or, better still, is made of hard steel. In these cases there is a lag in magnetisation due to either eddy currents set up in the bar or to hysteresis, and the result is a lateral escape of lines of force out of the bar when it is held with one extremity on an alternating magnetic pole. Then there is in these cases an action which is a true "magnetic self-induction." In the case of electric circuits, if we join in parallel two circuits, one having very small ohmic resistance and very high self-induction, and the other very large ohmic resistance and small self-induction, a sudden flow of current chiefly selects the path of least self-induction for its flow during the variable period, although

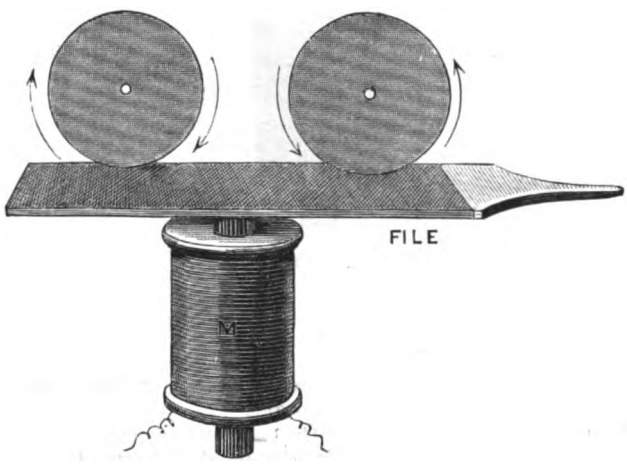

Fig. 30.

during its steady period it will chiefly flow by the path of smallest ohmic resistance; so in the case of a magnetic and conductive circuit of low magnetic and electric resistance (iron), shunted by a path of high magnetic and electric resistance (air), rapid variations of magnetic induction bring about a state of things in which the magnetic induction seems to chiefly select the

Fig. 31.

path not of least but of greatest magnetic resistance during the variable period. Time will not permit me to develope at greater length the analogies of the magnetic and electric circuits under the conditions of rapidly periodic magnetic induction and electric current; but there are many suggestive ideas which arise when we place before our minds the notion of a magnetic self-induction which is the consequence of a time-element coming into action in the setting-up of induction in a magnetic and conductive circuit, and due to the production of electric eddy currents, just as the electro-magnetic or ordinary self-induction is the consequence of the time element coming into action in the setting up of an electric current, and due to the production of a surrounding magnetic field. Just as the rise of current strength under an impressed electromotive force acting in a conducting circuit is retarded by linking that conductive circuit with a magnetic circuit, so the rise of magnetic induction under an impressed magnetising force, acting on a magnetic circuit, is retarded by linking that magnetic circuit with an electric conducting circuit. I am under the impression that Mr. Oliver Heaviside has developed these notions in a mathematical form, but am unable at the moment to place my hands on the results. The effect, however, of a bar of unlaminated iron when surrounded by a magnetising coil at one end and traversed by a periodic current is to cause rotation in copper or iron pivoted discs held near it, or when such a bar of non-laminated iron is abutted on the pole of an alternating magnet. A bar of steel, even if not laminated, is able to cause brisk rotations in copper or iron discs under the same circumstances. With hardened steel the action is more marked. Here the hysteresis retards the propagation of the magnetic wave. By laying a large file flatwise against the alternating magnetic pole at about the middle of the file, discs of copper or iron may be kept revolving if held over those portions of the file which project from the pole of the magnet (*see* Fig. 30). In this case the magnetic retardation in the bar is brought about by its own chemical structure, and not by embracing it with a closed conducting circuit. The result is, however, the same in kind; there is a sluggishness in the establishment of the magnetic induction on the steel or iron under the action of magnetising force which partly depends on eddy currents in the mass of the metal and partly on hysteresis.

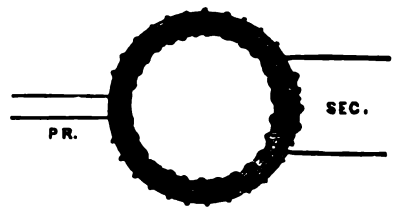

Fig. 32.

As a consequence we have a periodic lateral displacement of the field. This question of a magnetic leakage dependent on a retardation of induction deserves special attention in the case of commercial alternate-current transformers. Time will not permit me to enlarge on it here to any great extent; but I may observe that in the design of closed-iron circuit transformers this magnetic leakage should not be neglected.

In a closed iron circuit embraced at one part by a magnetising coil and subjected to rapidly reversed magnetic force, the magnetic induction does not confine itself wholly to the path of least magnetic resistance, viz., the iron path, but takes a short circuit in part across the interior air space. This waste field may in badly

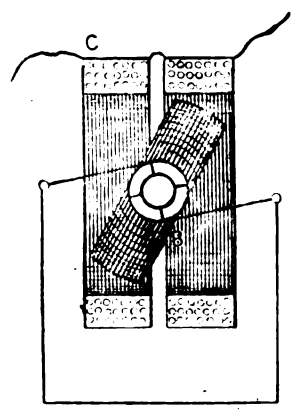

Fig. 33.

designed transformers be something considerable. I believe that an important point to hold in view in transformer construction is to subject the iron circuit uniformly to the magnetising force, by embracing all portions of the iron circuit with primary windings, and not locating the windings simply at one part. There is then a tendency to check the production of waste field by the lateral budging-out of the magnetic lines of force from the iron. In Fig. 31 is a diagram illustrating the arrangement primary and secondary coils most favourable for the production of waste field, and in Fig. 32 the arrangement least favourable for the same.

The foregoing experiments are of such a nature as obviously to force on us the thought that useful and perhaps important applications can be made in electro-magnetic machinery. Professor Elihu Thomson has, as you can imagine, not been slow to do this; for in

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him is united both a keen scientific sagacity and that clear mental vision which enables him to pursue to its logical issue in practice the consequences of scientific discovery. He has already applied these principles to the construction of alternating-current indicators, alternating-current arc lamps, regulating devices for alternating currents, and to rotary motors for such currents. For current indicators, a pivoted or suspended copper band or ring composed of thin washers piled together and insulated from one another and made to carry a pointer or index, has been placed in the axis of a coil conveying alternating currents whose amount or potential is to be indicated. Gravity or a spring is used to bring the index to the zero of a divided scale, at which time the plane of the copper ring or band makes an angle of, say, 15 to 20 degrees with the plane of the coil. This angle is increased by deflection more or less great, according to the current traversing the coil. The instrument can be calibrated for set conditions of use. Time would not permit of a full description of these arrangements as made up to the present.

In arc lamps the magnet for forming the arc can be composed of a closed conductor, a coil for the passage of current, and an iron wire core. The repulsive action upon the closed conductor lifts and regulates the carbons in much the same manner that electro-magnets do when continuous currents are used. The electro-inductive repulsive action has also been applied to regulating devices for alternating currents, with the details of which I cannot now deal.

For the construction of an alternating-current motor which can be started from a state of rest the principle has also been applied, and it may here be remarked that a number of designs of such motors is practicable.

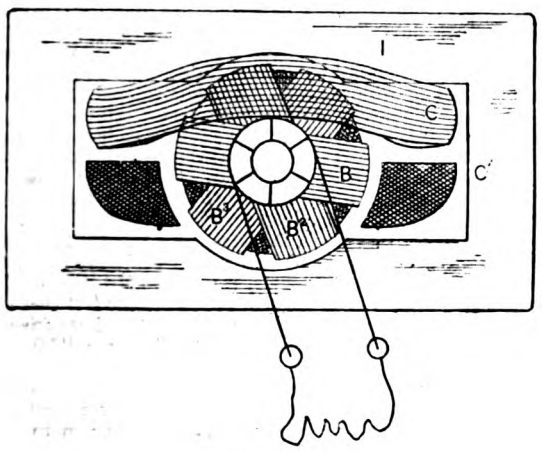

FIG. 34.

One of the simplest is as follows: The coils C, Fig. 33, are traversed by an alternating current and are placed over a coil B, mounted upon a horizontal axis, transverse to the axis of the coil C. The terminals of the coil B, which is wound with insulated wire, are carried to a commutator, the brushes being connected by a wire, as indicated. The commutator is so constructed as to keep the coil B on short circuit from the position of coincidence with the plane of C, to the position where the plane of B is at right angles to that of C; and to keep the coil B open-circuited from the right-angled position or thereabouts to the position of parallel or coincident planes. The deflective repulsion exhibited by B will, when its circuit is completed by the commutator and brushes, as described, act to place its plane at right angles to that of C, but being then open-circuited its momentum carries it to the position just past parallelism, at which moment it is again short-circuited, and so on. It is capable of very rapid rotation, but its energy is small. He has extended the principle to the construction of more complete apparatus. One form has its revolving portion or armature composed of a number of sheet-iron discs wound as usual with three coils crossing near the shaft. The commutator is arranged to short-circuit each of these coils in succession, and twice in a revolution, and for a period of 90 degrees of rotation each. The field coils surround the armature, and there is a laminated iron field structure completing the magnetic circuit.

In Figs. 34 and 35, we have diagrams which will give an idea of the construction of the motor referred to. C C′ are the field coils or inducing coils, which alone are put into the actuating alternating circuit. I I is a mass of laminated iron, in the interior of which the armature revolves with its three coils, B, B^2, B^3, wound on a core of sheet-iron discs. The commutator short-circuits the armature coils in succession in the proper positions to utilise the repulsive effect set up by the currents which are induced in them by the alternations in the field coils. The motor has no dead point, and will start from a state of rest and give out considerable power, but with what efficiency is not yet known. A curious property of the machine is that at a certain speed, depending on the rapidity of the alternations in the coil C, a continuous current passes from one commutator brush to the other, and it thus performs the function of converting some electric energy from an alternating to a continuous form.

A small motor of a curious type has been made, utilising the principle of "shading" the pole by closed circuits. A laminated ring (Fig. 36) is wound over with wire, but has a slot cut through

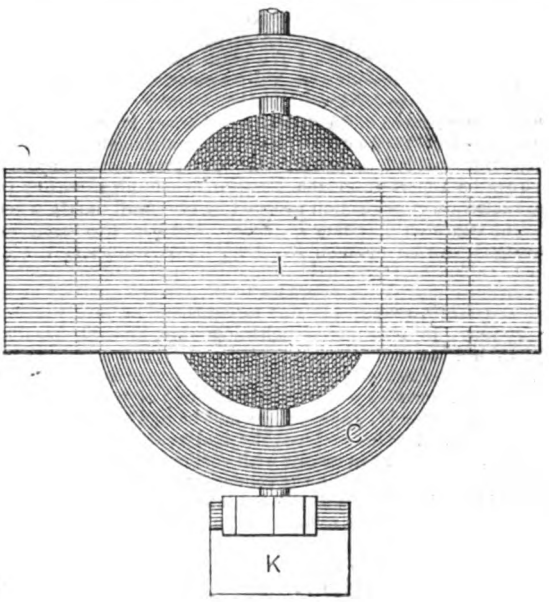

FIG. 35.

it, dividing the ring and causing it to present two pole faces opposite to each other at the cut part. Each pole is arranged by a set of closed copper bands to be "shaded." A copper disc, free to turn on a shaft, is introduced by one edge into the air-gap in the magnet, and turns rapidly when the magnet is excited. A silver coin held just at the edge of the air-gap in such an alternating magnet with shaded poles, is drawn into the interpolar space and propelled with some force through the same; but a lead disc or coin of base metal is not acted upon nearly by the same force, owing to its inferior conductivity. I have left myself but little time to speak of numerous applications of these principles in alternating-current meters. The well-known meter of Mr. Schallenberger was described to you here quite recently by Professor Forbes. There is, however, a new form of meter, designed by Messrs. Wright and Ferranti, which exhibits in a most beautiful manner a practical application of some of those principles which have briefly occupied our attention (*The Electrician*, May 16th, 1890, p. 32.)

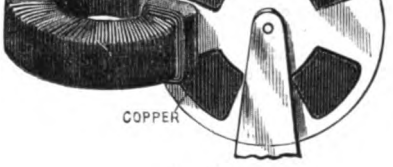

FIG. 36.

It would take me beyond the limits of the time during which I am permitted to trespass upon your attention if I were to attempt to exhaust the list of electro-motor applications that have been made of these electro-magnetic repulsions. That is a subject important enough to deserve a separate treatment. In Berlin, not long ago, I saw a most ingenious form of self-starting alternating-current motor, the invention of Herr von Dolivo Dobrowolsky, in which the rotating portion was merely a solid iron cylinder constituting a commutatorless armature, revolving in an alternating field, and which acted in a perfectly marvellous manner. The region of practical invention here opened is a very wide one: and I have, therefore, ventured to direct your thoughts to it to-night, confident that its character in this respect deserves all the attention it can obtain, and that a firm foundation for it is laid in these interesting researches of Prof. Elihu Thomson.

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ON LIGHTNING-GUARDS FOR TELEGRAPHIC PURPOSES, AND ON THE PROTECTION OF CABLES FROM LIGHTNING.

The following is an abstract report of the discussion on the Paper read by Dr. OLIVER LODGE before the Institution of Electrical Engineers, on April 24th :—

Mr. SAUNDERS said he got the idea of his lightning guard in 1864, from noticing that a cable was connected to a land line through a fine wire enclosed in a glass tube. These wires were frequently fused, and the tubes broken, so he replaced the glass tube by a brass one connected to earth. After this fusions were less frequent. Sir W. Thomson brought out a similar device in 1872, quite independently. From the fact that in his practical experience of 25 years he had never known a cable or instrument protected by his guard to be damaged, although the wires had been often fused, he was led to believe that the arrangement was a good one. He then read a report from the Eastern Telegraph Company relating to a remarkable case of protection afforded by his guard during a very sudden and violent storm on February 14, 1888. The wire was fused, but nothing else damaged. In his opinion, Dr. Lodge over-estimates the chances of damage to cables, for instruments and other apparatus are more frequently injured than cables. With reference to Dr. Lodge's question as to whether unexplained faults may not be due to lightning, he said that such faults were very few. Injuries due to lightning were, he said, usually near the ends of cables, but even these were of rare occurrence. As regards Dr. Lodge's guard, Mr. Saunders thought it very ingenious, but before it could be pronounced successful it must stand the test of practical use. In reply to questions from Sir W. Thomson, he said he had never known condensers to be damaged. In the accident he had referred to he could not say whether the cables were in circuit with condensers or not.

Sir W. THOMSON thought the condenser ordinarily used for signalling would be, in conjunction with the Saunders's fuse wire, an efficient protection for cables, for the quantity of electricity required to make the difference of potentials between the plates considerable would probably be more than sufficient to fuse the wire ; hence the cable could never be raised to a dangerously high potential. He asked Mr. Saunders for the particulars of the wires generally used, and was informed that their length was 15 inches, diameter ·0027 inch, and resistance 45 ohms. These, Mr. Saunders said, were frequently fused. Sir W. Thomson (continuing) said that in a lightning discharge it was probable that any free passage to earth would be taken advantage of ; it was, therefore, important to put the fine wire beyond the spark-cap protector. He considered that the new principle introduced in Dr. Lodge's self-inductive conductor, with graded spark-gap, might give valuable security when no condenser is used, and enhanced security even when there is a condenser.

Mr. PREECE said he wished to treat the question from a practical standpoint, but he was willing to admit that some attention must be paid to theory. In his opinion it was quite unnecessary to assume that lightning flashes were oscillatory in order to understand that self-induction may be beneficial in causing a discharge to jump over the spark gap, for all admit the sudden and rapid rise of the flashes ; and this was the only essential point. In considering the question as to whether a necessity exists for a novel lightning protector, he pointed out that such an apparatus should either fill a want, give greater efficiency, or be more economical than the ordinary protectors. With respect to the first condition he maintained that no want exists, for the common protectors answer all requirements. In support of this he quoted the Post Office returns for 1889, from which it appears that out of 600 valuable instruments, such as quadruplex, multiplex, Wheatstone automatics and repeaters, not a single one had suffered damage from lightning. This, he considered, was a strong proof of the efficiency of the methods of protection adopted. The protector consists of two circular plates separated by thin mica, or by a layer of air about $\frac{1}{100}$th of an inch thick ; the self-induction of the working instruments was sufficient to cause the spark to lead across the space. As to cables, he said that all the 117 under his charge were protected by the plate guards above described ; but, in addition, a coil and fuse wire were inserted between the plates and the cable. This method had been in use since 1879, with perfect success. During the interval only one case of damage had occurred, and in this considerable doubt existed as to whether the injury was caused by lightning or not. From these facts he concluded that no want for a new protector exists, and that none can give greater efficiency. As regards economy he said the ordinary protectors cost from 2s. 9d. to 3s. 6d., whilst those for cables were about £1. If anything could be gained by the use of Dr. Lodge's apparatus he (Mr. Preece) would be glad to try it ; but he would also use in addition one of the ordinary protectors which practical experience had shown to be successful.

Mr. CHARLES BRIGHT commented on the remarkable similarity in lightning guards, and said their pedigrees were very interesting. The devices of the earlier workers in the field, Steinheil, Breguet, Faraday and Walker, had been considerably improved by Varley, Siemens, Saunders and Jamieson. Steinheil, he thought, was the first to recognise the fact that the law of divided circuits was not true for rapid discharges. In Dr. Lodge's guard several new principles were involved, the chief of which seemed to be the introduction of self-induction by means of coils ; the protection from damage due to electricity surging up from the earth seemed to him an important feature, in which Dr. Lodge's apparatus differed from that of Mr. Saunders and others. Mr. Bright then directed attention to Sir Charles Bright's guard, and said that it was particularly useful in cable huts, for if one wire was fused the remaining ones were available. It also had the advantage (like Dr. Lodge's) over other guards of preventing the surging back from the earth, by the cable being entirely cut off from the earth at the moment when such surging back would tend to take place. He agreed with Dr. Lodge as to the uncertainty which must surround unexplained faults in cables, and thought that the best protection obtainable should be employed.

Captain STIFFE said that on the Persian Gulf cable he had used a protector consisting of a Siemens plate-guard and a fine platinum wire. Sometimes the wire was melted and the plates had been fused together, but no damage had resulted to the instruments or cable. Before the fine wire was introduced it was not uncommon to have the land-line instruments damaged.

Sir HENRY MANCE corroborated Captain Stiffe's statements, and said that since the Persian Gulf cable came under his charge he had modified the guard by winding the fine wire into a spiral, and enclosing it in a glass tube to prevent mechanical injury. This, he thought, in combination with the plate-guard, somewhat resembled Dr. Lodge's arrangement of an air gap, followed by a coil having self-induction. He admitted that obscure faults do sometimes occur, but did not think they were due to lightning. Siemens' plate guards were fairly efficient, for the plates were rarely fused together ; more frequently their surfaces were merely pitted by the discharge. In conclusion, he asked Dr. Lodge whether the spiral connections from the land lines to the cable and the coiled ends of the cable would tend to protect by virtue of their self-induction.

Major CARDEW thought Dr. Lodge's apparatus was not necessary for ordinary lines. Speaking of the experiments shown at the previous meeting, he pointed out that the unprotected terminals were always struck ; whereas in practice it was possible that the protected terminals might receive the discharge. If, as Dr. Lodge supposed, the line was struck outside the station, then, even at a comparatively short distance away, the impedance of the line would exceed that of Dr. Lodge's coils, and a kind of spark gap exist at each insulator. The successive spans and insulators would thus act as the coils and spark gaps in Dr. Lodge's apparatus.

Prof. HUGHES considered the communication under discussion very important, inasmuch as it recognises the value of impedance in lightning protectors. Many of the older protectors contained analogous arrangements, but their inventors failed to see their importance. Breguet's protector, for example, consists of fine insulated iron wire wound on a brass tube, and surrounded by another tube, both tubes being earthed. Each convolution of wire possesses self-induction, and the insulation acts as a spark gap, so that in effect the protector consists of a very large number of spark gaps in parallel and impedance coils in series. Referring to the cause of the galvanometer kicks about which Dr. Lodge had quoted his opinion, he said that the effect was due to a complicated series of actions ; and although he agreed with Dr. Lodge's notions on the subject, he still thought the main cause thermo-electric.

General WEBBER said one of the advantages of such Papers as the one before them was that they called forth such valuable records of practical experience as those presented by Mr. Preece and Mr. Saunders. No one, excepting Major Cardew casually, had referred to the fact that in ordinary telegraph lines points of release occur at every insulator ; from his own observations on storms in the eastern counties between 1870 and 1874, he was inclined to think that more protection of the offices was due to this cause than to any other. As regards electric light circuits he inquired whether bare or covered underground conductors were most likely to be damaged by lightning. Overhead wires, he believed, were much more likely to be injured than underground ones. Some time ago in his own house, which was then lighted by 25 volt lamps, he noticed, or thought he noticed, the lamps go dark immediately after a vivid lightning flash, and again regain incandescence. The effect he attributed to some inductive state of the earth at the moment of the flash, for an arc lamp in the vicinity was destroyed by the same discharge.

Prof. AYRTON pointed out that the lightning protectors of Mr. Preece and Mr. Saunders could not be applied to electric light circuits ; for it was admitted that plate protectors were insufficient, and the fine wire, an essential part of the arrangements, was inadmissable on account of the strong currents employed. Speaking of damage to telegraphic apparatus, he said he had known polarised relays to be frequently reversed by lightning. In one instance he saw a flash strike a line about a quarter of a mile from the station; every insulator between the point struck, and the station was smashed, the relays fused, and all the instruments damaged, although there was a plate-protector on the line in the office. This, in his opinion, showed that the self-induction of the spans, and the points of release at the posts referred to by Major Cardew and General Webber were insufficient protectors.

Mr. MORDEY said that it was not so much the lightning that was to be feared in electric light circuits, as the current from the dynamo following the path of the discharge, and forming an arc. Means must be devised for breaking up such arcs, and it was more in this direction that electric light engineers were working. Electro-magnetic cut-outs actuated by the currents forming the arcs had been tried for this purpose, and Prof. Elihu Thomson's device for blowing out the arc by a magnet energised by the arc current was in actual use in America.

Mr. SPAGNOLETTI recalled an instance of lightning striking an aerial line, and completely demolishing all the insulators and arms on ten poles, as well as splitting the poles themselves into fragments. In another case a man was killed at Shrewsbury by a flash that struck the line 50 miles away; and on the Metropolitan line he had known an instrument in the centre of a tunnel to be fused, although all the wires connected with it were underground. These cases seemed to show that the protection afforded at the poles referred to by Major Cardew and General Webber to be quite insufficient.

Mr. CROMPTON made inquiries as to how electric light circuits were to be protected, and wished to know if it was necessary to put protectors in each house, or whether protectors at both ends of the leads would be sufficient.

Dr. LODGE said that judging from the statements of several of the speakers the ordinary protectors did their work well, but they were all

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open to the objection that they were frequently damaged. Whenever protectors were damaged, he contended that something else had also been damaged, although the injury might not be visible. He could hardly accept the statements made by men of experience that they never came across faults that could not be accounted for, and he maintained that any unexplained fault *may* be due to lightning. Even a fraction of 3,000 volts, corresponding to a millimetre spark, might seriously injure a cable. As regards the advantages of fine wire, its use was essential to complete safety. In his Paper he had pointed out that two things had to be guarded against, viz., high potentials and strong currents. His apparatus reduced the high potential, and fine wire was a protection against strong currents. As pointed out by Sir W. Thomson, the fine wire should be at the protected terminals. In reply to Mr. Preece's statement that the self-induction of instruments was sufficient to cause the spark to jump across air spaces, he said that if the coils were wound on iron cores or metal reels, the self-induction for flashes was negligible, and in any case lightning would take no notice of silk or cotton insulation. Moreover, self-induction alone, without supplementary air-gaps, was not sufficient. Corkscrew bits of wire used for convexion had also been appealed to, but the shapes of these coils were by no means such as would give maximum self-induction. He thought Sir W. Thomson's suggestion concerning the fine wire and a condenser might account for some instances of present protection. Referring to Breguet's protector, mentioned by Prof. Hughes, he pointed out that the self-induction of the silk-covered wire was non-existent for lightning flashes. Self-induction, as such, was not the essence of his own apparatus, for an efficient protector requires successive spark-gaps with self-induction between them. In reply to Major Cardew, he said that in his experiments he had imitated the circumstances most likely to occur. As to the relative danger to underground and overhead wires he pointed out that the former were not entirely underground; if they were they would be secure. Covered underground conductors would be more likely to be injured than bare ones, for the insulation of the former might be punctured, whilst the latter could only be damaged by fusion, and this was not likely to occur. He suggested that the lamp phenomenon observed by General Webber might be due to a momentary short-circuiting of the leads by induction from the lightning flash, for he himself once had his storage battery leads short-circuited by resonance sparks caused by discharges in his experiments on lightning conductors. In answer to Mr. Crompton's inquiry Dr. Lodge thought the same principle as is used in protecting buildings from fire by means of fireproof doors should be adopted, and protectors should be placed wherever underground wires leave the earth.

LEGAL INTELLIGENCE.

King, Brown, and Co. v. The Anglo-American Brush Electric Light Corporation.

The reclaiming note by the Anglo-American Brush Electric Light Corporation (Limited)—now known as the Brush Electrical Engineering Company—against the interlocutor of Lord Trayner in the action against them at the instance of King, Brown, and Co., Edinburgh, for the reduction of their patent for series-shunt-wound dynamo machines, came before the First Division of the Court of Session on Wednesday last, the Judges on the Bench being the Lord President and Lords Adam and McLaren. The Lord Ordinary reduced the patent as craved, and found the defenders liable in expenses, holding that the defenders' commutator claim was invalid in respect that the invention claimed in the final specification was larger and different from that claimed in the provisional specification, and that the series-shunt machine was used and publicly known prior to the date of the defenders' letters patent (1878), their machine having been anticipated by the publication of Varley's specification in 1876, and by the use of a machine made according to Varley's specification.

The reclaimers were represented by the Dean of Faculty, Q.C., and Mr. Jameson, instructed by Mackenzie, Innes, and Logan, W.S.; and the respondents by Mr. Graham Murray, Mr. Dickson, and Mr. Daniells, instructed by Davidson and Syme, W.S.

Mr. JAMESON, for the reclaimers, said this was an action of reduction of Brush's patent—a patent which was taken out originally in America, but which was brought here by a communication from America, and was patented by a patent agent of the name of Haddan. It was, therefore, called Haddan's patent throughout the evidence; but perhaps it would be convenient for him to refer to it as Brush's patent. The action of reduction was brought in consequence of an action of putting to silence that was brought by King, Brown, and Co., in consequence of what then were threats administered to them by the Brush Company, for having manufactured compound-wound or series-shunt machines. That action came before their Lordships, and there was a question whether it should proceed first or follow an action brought by the Brush Company against the Orient Company. It was suggested that King, Brown, and Co. should try the question by means of a reduction. Following that suggestion that reduction was brought. There were a number of grounds of reduction set forth in the record, but the grounds which were now founded upon by the pursuers resolved themselves into two or three. They saw, in the first place, in regard to the commutators of that machine, that they were neither original nor useful. He did not know exactly how far the pursuers were going to maintain all their pleas; but he was attacking the Lord Ordinary's interlocutor upon the three grounds which he took up, and in his speech he would only deal with these three points. These points were—first, that with regard to the commutators of Brush's patent, in the completed specification there was something set forth that was not sufficiently shadowed forth in the provisional specification. That was the point against them with regard to the commutators. Then with regard to the main part of the machine, the Lord Ordinary held that that discovery was anticipated by the publication of the patent of Varley in 1876; and the third ground was that the invention was publicly used by that machine of Varley prior to the patent. Brush's patent, as regarded this country, was taken out in 1878, while Varley's was taken out in 1876; but there was this remarkable difference between them, that whereas Brush's patent had been practically used ever since, and hundreds of machines made in accordance with it, Varley's patent had never been heard of until the single machine made in accordance with it was disinterred from a lot of rubbish in the shop of the persons who made it, and brought forward in a previous action—an action which was settled by the parties paying the Brush Company a royalty.

Counsel then proceeded to explain the elementary principles underlying the dynamo. With regard to the commutator he did not know what the other side were going to maintain.

Mr. GRAHAM MURRAY said he was going to maintain that not only was the commutator patent bad in respect of inconsistency between the completed and the provisional specifications, but that it was also bad in respect of prior use.

Mr. JAMESON said the Lord Ordinary was against his friend upon the latter point. His Lordship thought their commutator new and meritorious. They by no means claimed the commutator as a new electrical invention, but that it was a patent on purely mechanical grounds. Returning to the subject of dynamo design counsel said that the question which occurred after Faraday's discovery was how were these armature coils to be kept in an electrical state; and the first and earliest way was to have permanent steel magnets. Then it was found that electro-magnets were very much more powerful than ordinary permanent magnets. These electro-magnets were energised by a voltaic battery, or by a small machine. In short, they got their magnetism for their machine from an independent external source. Then it struck some proficients that they might get the electricity for the magnets from the machine itself. That might be done by having a number of bobbins upon the armature devoted to that work alone. Then a very good idea struck some electricians—he thought there were three people who brought it out at once—and that was known as a series-wound dynamo.

Counsel then briefly described the series dynamo, and referred to the objections which existed in connection with it. Then he described the shunt dynamo, in regard to which he said a communication was read to the Royal Society by Sir Charles Wheatstone. In a shunt machine the current from the armature was split at a terminal, and led into two paths—one of low resistance and the other of greater resistance, called the shunt wire. The objection to the shunt machine was that if you had the useful work of the machine increased in the parallel system you had great loss of magnetism in the magnets. It was in order to provide against this fault that Mr. Brush set himself to invent his machine. He would read what Mr. Brush said about his object in doing so. Mr. Brush said:—"The object of my invention was the production of a dynamo-electric machine that would automatically maintain a substantially or sufficiently constant potential under varying amounts of work in its external or working circuit. In other words, a dynamo that would be adapted automatically to operate normally a small quantity of work as well as a large quantity in its external circuit." The way he accomplished that object of automatic regulation was by combining the series and shunt principles together—by winding the magnets both with a series wire and with a shunt wire, so that in that way they got rid of the specific objections to either form of winding separately used. In a series-shunt machine the series wire current went to the electric light, came back to the machine, went round the magnets, and returned again into the armature. In the same way the current was bifurcated, and went by the shunt wire, travelled round the magnets, and returned to the armature. A great deal was said in the evidence about constant potential. It had been suggested that Brush did not appreciate constant potential. There was no doubt that constant potential had become of more importance since incandescent lighting came into vogue. Brush pointed out, and all the witnesses admitted, that his machine was an endeavour towards automatic regulation of a dynamo, and of course that led to the perfection of the means of attaining constant potential. Although constant potential was not precisely the object he was aiming at—it was automatic regulation he wished to attain—it was proved he practically attained a very near approximation of constant potential.

LORD McLAREN: Is constant potential produced, in consequence of the series-shunt arrangement, always exciting the magnets uniformly?

Mr. JAMESON: No, proportionately to the work done. Continuing, he said he had now sufficiently described the general characteristics of these machines, and he would now proceed to point out the features of the Brush machine. Having shown the machine to the Bench, Mr. Jameson drew attention more particularly to the commutator. There was, first, an insulating hub made of wood, or some other insulating material: the wires were brought into it, and were brought up through little holes into electrical connection with the brass sub-segments, and through these were passed what were called detachably-attached segments of copper in electrical connection again with the brass. These were screwed on by screws of a peculiar construction. They were screws which had more head than tail, and the head was a large, long head which went down through this segment, and the tail was screwed into a brass sub-segment beneath. The great advantage of the arrangement was this, that when this was worn away by constant friction with the brush, they could, without disturbing the electrical connection, just unscrew this copper segment, take it off, and put a new one in its place. That was one of the great advantages of the Brush invention.

LORD ADAM: That does not seem anything very marvellous.

Mr. JAMESON explained that it was a very convenient arrangement. The thing could be unscrewed with the greatest ease without being prised off with hammers and chisels.

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LORD McLAREN: You just put a new surface on it.

Mr. JAMESON replied in the affirmative. He now went to the provisional specification of Haddan's patent, No. 2,003, of 1878. According to the specification that invention consisted in the construction and use of annular metal armatures grooved on their peripheries or sides or both, and insulated partly or entirely from each other; also in constructing commutators cylindrical to an insulating hub or body, to which were attached metallic sub-segments placed in electrical connection with the general mechanism in which the commutator was employed, and metallic wearing segments detachably attached to said sub-segments. He submitted that this was a sufficient general description of the commutators of this machine. They were cylindrical, and there was an arrangement tending to preserve their cylindricity in this, that they had got screws of a peculiar kind—that they had got an arrangement, without taking off the copper segments, so as to have the cylindricity of this constantly preserved, with an insulating hub or body that was obtained by means of large wires which were insulated from each other, and also insulated from the shaft, "to which are attached metallic sub-segments." These were segments placed in electrical connection with the general mechanism in which the commutator was employed. "Metallic wearing segments detachably attached to the sub-segments." These were attached in such a manner that they could be easily detached from each other by means of the screws. Dealing next with the final specification, Mr. Jameson referred their Lordships to p. 16, which set forth the following description: 1. An annular armature consisting of two or more plates formed with grooved sides or peripheries, or both, and insulated entirely from each other, substantially as shown in division No. 2. 2. A commutator cylinder, consisting of an insulating hub or body, to which are attached sub-segments placed in proper electrical connection with the general mechanism in which the commutator is employed, and wearing segments detachably attached to said sub-segments, substantially as shown in division 3. 3. The combination of sub-segments R, wearing segments S or T, screws K, substantially as and for the purposes shown in division 3. 4. The commutator having metallic insulating segments T, substantially as shown in division 3. 5. A commutator, having metallic insulating segments T, attached to and forming part of the adjoining conducting segments S, substantially as shown in division 3. 6 A commutator having two conducting segments, S, two opposing ends of which said segments are separated by an intervening insulator, T; the other ends of said segments, while insulated from each other, being closely associated, and not provided with an insulator T, substantially as shown in division 3. The criticism made upon No. 2 was that it exceeded the whole of the provisional specification. In one sense it did so. The patentee gave a general description of the commutator, and then, as he must take every part of his invention in order that he might not be cut out by some person subsequently claiming part of it and omitting the rest, or claiming part of it and adding something to it, the patentee then went on to No. 6, to complete his claim under this head. He (Mr. Jameson) submitted that all these matters were properly and sufficiently foreshadowed in the provisional specification. No. 2 was a general description; No. 3 was a combination of the three parts of what made up the commutator; No. 4 was, again, just a single integer of the combination, viz., the insulating segment T; No. 5 was an attachment to the insulating segment T, so as to make it a conducting as well as an insulating segment. Now, keeping in view that this invention was merely one of mechanical details, and not of any electrical principle, this was a description of a particular commutator.

LORD McLAREN: How is this an insulating segment?

Mr. JAMESON: It comes between two segments which were in electrical connection with the bobbins, and had the effect of cutting the bobbin out at that particular point.

LORD McLAREN: So far as regards the bobbins the part of the armature that was previously at work is no longer insulated from the next one?

Mr. JAMESON: It might be entirely detached, in which case the only use of it would be to keep up the cylindrical form without having any detachment whatever. It did good in this way—that it presented a larger surface to the brush. It made a larger surface between the brush and that wire which was in connection with the electric current. It was insulated with reference to the segments on either side, but it did not insulate with reference to segments to which it was attached. He did not say that it had great electrical advantages, but it tended to make the machine special. Two rounds of copper connected with each other conduced to the rigidity of the whole commutator. Now, it was said that was not properly foreshadowed; and Lord Trayner had adopted that view. Well, first as regarded the commutator, Mr. Brush described his invention in the provisional specification in these terms: "In constructing commutators, cylindrical, with an insulating hub or body, to which are attached metallic sub-segments placed in electrical connection with two wires, with the general mechanism with which the commutator is employed, and wearing segments detachably attached to said sub-segments." He held there was nothing uncommon in a patentee claiming not only the combination of a great number of details, but also claiming one of these details by itself as a separate and independent claim; and if this was set forth in the provisional specification, the machine, described as a whole, did not put aside what he claimed for particular parts. He might claim any part of it whole, or any integer, or any combination of two or more integers of the whole, with the view of preventing his patent being infringed. Lord Trayner seems to have said that in the provisional specification they must not only generally describe the invention, which he understood was all that was required; but it must be done sufficiently to allow the invention to be known. The provisional specification was in order to secure a patentee's invention, and then he got six months to perfect it, and give a final specification. It was time given to him to perfect his invention and work out the details, and in working out the details he would find out what his invention was worth, and would put in a claim for the patent, not only as a whole, but also for parts of his invention.

LORD McLAREN: The thing Lord Trayner holds against seems to be an important part of the final specification. It occurs to me that the process in this case might be suited to allow the Brush Company to disclaim this part, as was done in the case of Sir William Thomson.

The LORD PRESIDENT: Is not that too late now?

Mr. MURRAY: In Sir William Thomson's case the disclaimer was made before the judgment. It is a very arguable point whether it could be done now.

The LORD PRESIDENT: There is a good deal disclaimed already.

Mr. JAMESON: A good deal, my Lord. The whole of the shunt arrangement was disclaimed because, at the date of this patent, Mr. Brush did not know it had been patented at all. It turned out that something approaching shunt had been foreshadowed by Sir Charles Wheatstone in a communication to the Royal Society.

LORD McLAREN: He now claims the shunt and series as what is known as compound winding.

Mr. JAMESON: That is so.

The hearing was adjourned till yesterday (Thursday).

Watt v. Maxim-Weston Electric Light.

This was an appeal from Mr. Justice North refusing to order a counter-claim by the defendant company to be struck out, which came before the Appeal Court, consisting of Lords Justices Cotton, Lindley, and Bowen, on Friday last.

Mr. Higgins, Q.C., and Mr. G. F. Hart, instructed by Messrs. Michael Abrahams and Son, appeared for the appellant; Mr. Cozens-Hardy, Q.C., and Mr. Gazdar for the respondents.

This action was brought by Mr. Hugh Watt, late managing director of the Company, for a number of liquidated demands, such as arrears of salary, rent of offices, &c., and also for damages in respect of certain shares, transfers of which the Company declined to register. He originally claimed a mandatory order directing transfers to be registered; but on the Company going into voluntary liquidation for purposes of reconstruction, this claim was changed into one for damages. Mr. Watt and others dissented from the reconstruction scheme, thereupon they were entitled to have the value of their interest ascertained, but an agreement was come to that the value of the shares should be taken at 1s. 6d. In Mr. Watt's case, however, there was a further dispute as to the number of shares to which he was beneficially entitled, and that question was referred to the arbitration of Mr. Frederick Whinney. The plaintiff claimed to be entitled to 7,376 shares; but Mr. Whinney, by his award, declared him entitled to 4,416, and to a further number of 2,710 if he paid up 5s. a share upon them to the Company. The counter-claim was for the calls on these shares; and the appellant sought to have it struck out on a variety of grounds, but mainly because, as he alleged, it was frivolous and vexatious, and disclosed no ground of action. There was also a technical ground, that it had been introduced without leave, but that Mr. Justice North had dealt with, by giving leave at the time of the application before him.

Their Lordships, without calling upon Mr. Cozens-Hardy, dismissed the appeal, Lord Justice LINDLEY saying that it was one which ought never to have been brought.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 15, 1890.

Meeting of the American Institute of Electrical Engineers.—The meeting of the American Institute of Electrical Engineers, to be held in Boston next week, promises to be of unusual interest. It will be held at the Massachusetts Institute of Technology, and bids fair to be attended by a large proportion of the well-known electricians in this section of the country. The Papers promised are of importance, and one of them is likely to throw a good deal of light on the much-talked-of question of high-speed electrical traction. It is to be read by Mr. O. T. Crosby, chief engineer of the Weems electric railway system, and his subject is "The Limitations of Steam and Electrical Transportation." The author has worked out this problem with great care, and has the invaluable resources of an unusually large practical experience. The Paper is one which will command attention from electricians interested in electrical traction. There will also be some valuable experimental demonstrations of the capacities of the automatic electric welding machines, by Mr. Lemp, well-known by his connection with the Thomson-Houston Company. From year to year these meetings of the Institute grow to be of more importance and value.

The Wenstrom Dynamo.—A very vigorous effort is being made to push the Wenstrom dynamos and motors in this country. A company, with a capital of a million dollars, has been organised in Baltimore for the purpose of manufacturing these machines, and a well-known firm of electrical engineers has taken the agency for them and proposes to push the business in the most vigorous manner. The Wenstrom is comparatively

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little known at present in this country, but its reputation is good, and the tests that have been made have been of a very satisfactory character.

The Duncan Slow-speed Motor.—A new slow-speed motor has just been patented by Dr. Louis Duncan, of Johns-Hopkins University, of Baltimore. It is a multipolar machine, with revolving field-magnets, and the arrangement of the poles and armature is such as will unquestionably give a very powerful torque and a considerable degree of efficiency. It is rumoured that the machine is to be for very low speeds, and, from its form, and this valuable characteristic, it may prove no inconsiderable factor in electrical traction business in the future. It is too early to speak more in detail. The machine seems to be distinctly a meritorious one.

Rapid Transit in New York.—The hopes of New Yorkers for rapid transit are rather nipped in the bud by the inefficiency of the New York Legislature in dealing with the subject. It was hoped that, for the sake of the long-suffering public, a franchise would be granted that would enable us to have electric or cable roads, or both, within a short time. The travelling facilities in the city are entirely inadequate at present to the needs of the time, and there is a strong movement towards doing something effective without further delay. The Real Estate Exchange of this city, realising how important the subject is to the growth and development of the outlying districts of Manhattan Island, have addressed vigorous remarks to Governor Hill on the subject, and it is to be hoped that some good result will come therefrom.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *May* 24, 1890.

The installation at the Gare de l'Est, to which I briefly alluded in a previous letter, is of a very complete character. The generating plant is situated in the Faubourg St. Martin, and the station is arranged on the American principle, that is to say, the steam engines and dynamos are placed on the ground floor, the switchboards on the first floor and boilers on the second floor. The boilers are of the Bellville type, the steam engines of the Weyher and Richmond type, and the 3100 kilowatt dynamos are of the Manchester pattern, made by the firm of Sautter-Lemonier, who undertook the whole of this installation. The distribution is carried out on the three-wire system at a pressure of 70 volts, and comprises 130 arc lamps, taking 850 amperes and 1,500 incandescent lamps, requiring a current of 1,180 amperes. The dynamos are direct belt-driven, and run at 300 revolutions. At this speed, with an exciting current of thirty amperes, each machine generates 1,200 amperes at a pressure of eighty volts. As a rule, two machines only are used, but the third is kept running slowly in case of a breakdown. As only one machine is kept running in the daytime, two of the three mains are joined together.

Up to the present the use of alternating currents seems likely to hold its own against continuous currents for the lighting of La Belle Jardinière, which I mentioned in my last letter. The struggle, however, is not over yet, and there is still room for hope that the municipal authorities will not make the mistake of establishing a special circuit with a pressure of 2,400 volts, in order to supply light to a customer only a quarter of a mile away from the municipal station, from which a distribution at 200 volts is already in operation.

In his recent address to the Société Internationale des Électriciens, M. Hippolyte Fontaine gives some interesting figures with regard to the electric light in Paris. At the present moment there are 6,800 arc lamps and 118,000 incandescent lamps in use in this city. In 1877 the electric light was represented by 65 *bougies-décimales* hours per inhabitant, in 1883 by 230, and in 1889 by 2,130. According to M. Fontaine gas furnishes 57·3 per cent., and electricity 18·9 per cent. of the total light of Paris.

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *May* 24, 1890.

Mr. Edison is expected to visit Vienna shortly, and great preparations are being made by the Vienna Electro-Technical Society to give him a fitting reception.

It is an ill wind that blows nobody any good. The riots in Biale, and the fear of riots on May 1st, opened many an official eye to the great value of telephonic communication. In Biale nearly the whole of the arrangements for protecting the twin towns of Bielig and Biale were done by telephone. Two new lines had to be put up for the town authorities, and one for the commander of the troops. At a banquet given by the town to the officers, it was acknowledged that without the telephone the service of protecting the town could not have been carried on as well as it was. In all other towns the police and town authorities felt the necessity of increased telephonic communication, especially in Vienna; and the result has been that many a new exchange subscription was contracted. So much was thought of the value of uninterrupted telephonic communication that the long pole routes in some of the towns were watched by cavalry patrols.

The Austrian Government have opened a large number of small exchanges during 1888 and 1889; and up to December 31, 1889, the totals were 62 call offices and 662 subscribers. The following trunk lines have also been opened by the Austrian Government:—Vienna to Brünn (Van Rysselberghe); Vienna to Prague (separate line); Vienna to Budapest (three wires); Vienna to Reichenau; Vienna to Baden; Vienna to Vöslau; Vienna to Wiener-Neustadt; Vienna to Neunkirchen; Vienna to Mödling; Aussig to Brüx; Aussig to Karbitz; Aussig to Mariaschein; Aussig to Teplitz; Aussig to Dux. This year the Government intend running the lines between Prague and Pilsen; Prague and Aussig and Tiplitz; Reichenberg and Gablonz; and Reichberg and Friedland. Next year they propose running a line from Vienna to Trieste, another from Vienna to Graz, and also a new separate line from Vienna to Brünn, to supersede the present Van Rysselberghe line, and finally a line from Prague to Brünn.

The Karlsbad Town Council have voted the sums necessary for the electric lighting of the town. Messrs. Ganz and Co.'s plans have been accepted, and the work is to be completed before the next season begins. Zizkor, a suburb of Prague, has now been lit up for some time by the electric light. The dynamos and electrical apparatus were supplied by Messrs. Krizik. Mr. Krizik's name is not much known in England, though his lamps are well known under the name of the Pilsen-Joel lamp, Pilsen being Mr. Krizik's home at the time. Mr. Krizik has applied for a concession to connect the lovely Belvedere gardens in Prague with the Baumgarten Park by an electric railway. In Brünn a company is being formed for central-station lighting, with the help of that enterprising and ubiquitous firm, Messrs. Ganz and Co., of Budapest. The Vienna Houses of Parliament are also lit by electric light, the installations having been carried out by Messrs. Siemens and Halske. The hall of the Commons is lit up by 25 400 candle-power, and 60 16 candle-power glow lamps. The Budget Commission Room is lit by two fine lustres, each with 30 16 candle-power lamps. The hall of the Upper House is lit in the same way as the Lower House, but being smaller, with only 20 400 candle-power lamps.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The Public Libraries Committee of Newcastle-on-Tyne invite tenders for (1) providing and fixing all lamps, wires, and fittings for an installation of the electric light at the Public Library in New Bridge-street; (2) supply of electric energy for the working of lamps, &c., for a minimum average of eight units per hour during the lighting season. Specifications and plans may be inspected and forms of tender obtained at the City Engineer's office, Town Hall, on and after June 5th. Tenders, addressed to the Chairman of the Public Libraries Committee, must be in by June 19th. Further particulars are given in our advertisement pages.

SALE BY AUCTION.—We call our readers' attention to the sale by auction, on Tuesday and Wednesday next, of the electric plant, stock of machinery, utensils, &c., of the Schmidt Douglas Electric Works, Bradford. Catalogues are now ready, and the plant will be on view on Monday next and on the mornings of sale. Further particulars are given on page xiii. of our advertisements, and full information can be obtained of Mr. Edgar Musgrave, 1, Bank-street, Bradford; Mr. Thomas England, Town Hall-chambers, Halifax; or of the auctioneer, Mr. Wooller Jennings, 43, Old-market, Bradford.

PERSONAL.—Mr. Walter F. Jones, late representative of Messrs. Felten and Guilleaume, cable manufacturers, has joined the staff of Messrs. J. B. F. Andrews and Co., of 41, Parliament-street. Mr. Jones was previously with Messrs. Andrews in Glasgow.

ELECTRICAL ENGINEERING COMPANY of IRELAND.—This Company have taken large premises at 61, Dawson-street, Dublin, where they will carry on the business of electrical engineers. The position is advantageously adapted as a centre for electric lighting, several contracts for which the Company are at present carrying out.

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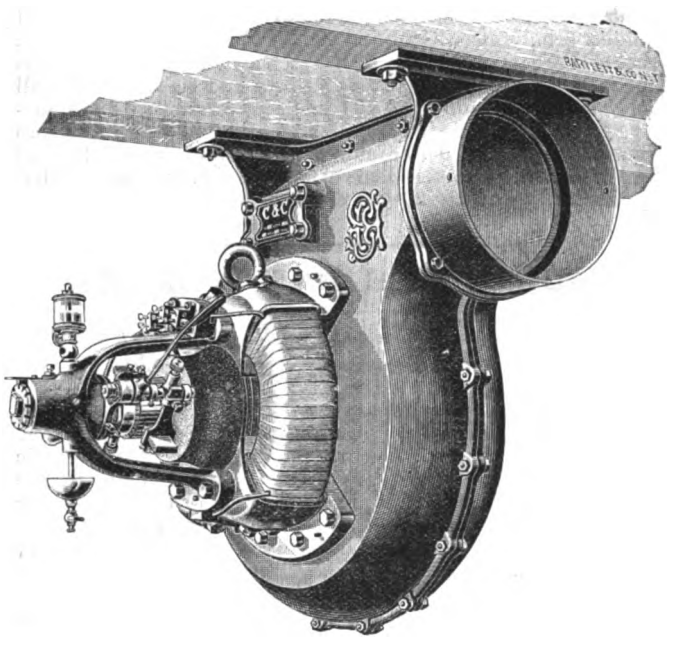
MESSRS. NALDER BROTHERS AND CO.—We have received this week the new (3rd) edition of the catalogue issued by this firm. It is very fully illustrated, and gives concise particulars, together with prices, of the well-known electrical instruments manufactured by them. The illustrations and descriptions include batteries and standard cells, condensers, electrometers, galvanometers, keys, ammeters, and voltmeters, secohmmeters, Ayrton and Perry's standard of self-induction, pocket micrometers, Newall's sensitometer, Prof. S. P. Thompson's new standard spherometer, resistance coils, the Poggendorff motor bridge, a portable testing set, &c., &c. The catalogue concludes with a number of illustrations and descriptions of electrical apparatus and instruments of which Messrs. Nalder Brothers are the manufacturers, specially selected from Prof. Ayrton's work on "Practical Electricity."

HERR G. WEHR, BERLIN.—We are in receipt of some admirably illustrated catalogues of electrical instruments and apparatus manufactured by this firm, in which illustrations, particulars and prices are given of telephones, microphones, electric bells, annunciators, switches, switch-boards, insulators, batteries, galvanometers, lightning conductors, and all kinds of apparatus connected with electric lighting, telegraphy, and telephony.

AN ELECTRIC BLOWER.

Proper ventilation is an important desideratum in modern vessels, and it is especially needful in the engine rooms, galleys, and those portions of the ship occupied by the crew. As shafting and belting are in most cases out of the question on board ship, the use of electricity as a motive power for driving ventilating fans has become very general. An electric blower can be put up anywhere, as the wire carrying the current can be easily run, and this application of the electric current provides a most convenient and in some cases the only means of renovating the air. The orifice of discharge in a blower is smaller in proportion to the amount of air passing through than that of any other machine for creating a forced draught of air; and this specially recommends it for ships



and in places where the discharged current of air has to be carried a distance in pipes, as the pipes required are small and no special provision need be made beforehand to allow space for them. The accompanying illustration is from a photograph of one of the "C and C" Electric Motor Company's electric blowers placed on the United States cruiser "Baltimore." It discharges 1,425 cubic feet of air per minute. Fastened to the ceiling of the dynamo-room, it completely changes the air of the room once every two minutes, discharging it at a distant point through a small pipe. The machine is very compact, and does its work so noiselessly that a person standing near cannot tell without the closest observation whether it is running or not. The ease with which electric blowers can be set up and connected to the dynamos, without requiring any shafting, belting or other contrivance except a small wire, has naturally brought them to the attention of shipbuilders.

Messrs. Shippey Brothers (Limited), of King-street, Cheapside, E.C., are the agents in this country for the "C & C" Company's manufactures.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.

April 19, 1890.

5,942. H. C. L. HOLDON. London. Improvements in the construction of electrical vent-sealing tubes for firing ordnance and like purposes.

April 21, 1890.

5,996. W. B. SAYERS. Putney. Improvements in electric incandescent lamps.

6,000. W. H. SCOTT, and LAURENCE, PARIS and SCOTT (Limited), Norwich. A new and improved method of making house or other connections with or without fuses to underground electric mains.

6,005. G. H. SAYER. London. Electric lamp adjuster.

6,032. M. W. DEWEY. London. Improvements in electric heating apparatus.

6,037. M. W. DEWEY. London. Improvements in and relating to electric railway vehicles.

April 22, 1890.

6,041. M. W. DEWEY. London. Improvements relating to the transformation and utilization of electrical energy.

6,082. J. E. WALLER and E. MANVILLE. London. Improvements in the means of and apparatus for distributing and collecting electricity for the propulsion of vehicles.

6,083. J. GORDON. London. Improvements in effecting the electric propulsion of tramcars and apparatus therefor.

6,100. J. SCOTT and F. E. DAVIS. London. Improvements in electric machines for covering wire.

6,120. C. J. KINTNER. London. Improvements in and relating to systems of electrical distribution.

6,124. J. F. MUNSIE. London. Improvements in manholes for underground electric circuits.

6,125. J. F. MUNSIE. London. Improvements in and relating to underground main and branch conduits for electrical conductors, and to feeding devices therefor.

6,126. R. D. RADCLIFFE. London. Improvements in electrical signalling apparatus for police service, and the like.

6,138. S. CLARKE. London. Improvements in screens or shades for lamps and gas or electric lights.

April 23, 1890.

6,156. G. SCHULTZ. London. An improved electrical switch for the better and more safe means of breaking the continuity of an electric circuit of high voltage, and again establishing the same.

April 24, 1890.

6,266. J. MARX. London. Improvements in means for use in electrolysis.

6,267. J. MARX. London. Improvements in means for connecting electrical conductors, applicable more especially for connecting conducting-wires or strips to electrodes used in electrolysis, and as a safety device for electrical purposes.

April 25, 1890.

6326. E. BATAULT. London. Improvements in electricity meters. (Date applied for under Patents Act, 1883, Section 103, 28th September, 1889, being date of application in Switzerland.)

April 26, 1890.

6,359. H. J. PEDDIE. Edinburgh. Improvements in the sections and forms of iron rails, in the method of laying them, and placing within them an electric conductor; and in the manner of applying the electric brush of an electric motor to the aforesaid electric conductor for use on electric tramways and railways.

6,372. G. COHEN. Manchester. Improvements in medical induction coils.

6,389. A. BLATTNER, London. An electric motor.

6,392. O. T. BLÁTHY, London. Improvements in safety-fuses for electric currents.

April 28, 1890.

6,475. W. LOWRIE and C. J. HALL. London. A safety device for electric circuits.

6,476. H. T. EAGAR and R. P. MILBURN. London. Improvements in electrical batteries.

6,490. E. SCHWEIZER. London. Electrical clockwork for pendulum timepieces.

6,492. M. W. DEWEY. London. Improvements in electric railways. [Date applied for under Patents Act, 1883, Sec. 103, November 2, 1889, being date of application in United States.]

6,493. M. W. DEWEY. London. Method of electric refrigeration. [Date applied for under Patents Act, 1883, Sec. 103, November 15, 1889, being date of application in United States.]

April 29, 1890.

6,568. H. H. LAKE. London. Improvements in and relating to electrical measuring instruments (M. M. Garver, United States).

6,569. H. H. LAKE. London. Improvements in electrical measuring instruments (E. Weston, United States).

6,570. M. W. DEWEY. London. Improvements in electric refrigerating apparatus for railway vehicles.

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6,581. H. H. LAKE. London. An improved method of repairing the carbon filaments of incandescent electric lamps (La Société L'Incandescence Electrique, France).

April 30, 1890.

6,623. J. WARDEN and G. SMITH. Birmingham. Improvement in switches for controlling electric colours for lamps and other purposes.

6,631. C. F. AIRD. London. Improvements in or relating to electrical apparatus partly for curative purposes.

6,632. R. MÉNARD. London. Improvements in or relating to electric igniting aparatus for gas and similar engines.

6,667. ALPHONSE FRAGER. London. An electric meter.

May 1, 1890.

6,726. F. V. HEFNER-ALTENECK. London. An electrical time-piece combined with installations for the distribution of electrical energy for lighting and other purposes.

May 2, 1890.

6,793. SIEMENS BROTHERS and Co. (Limited). London. Combined electro-magnetic coupling and brake apparatus (firm of Siemens and Halske, Germany).

6,801. A. B. HOLMES. Liverpool. Improvements in apparatus for testing leakage and insulation of electrical conductors.

6,810. A. P. SMITH. London. Improvements in apparatus for tapping water, gas, or other mains.

May 3, 1890.

6,841. C. R. G. SMYTHE and E. PAYNE. Glasgow. Improvements in and connected with electrical fuse boxes, switch boxes, and similar electrical fittings.

6,865. E. HARTMANN. London. Electrical apparatus for automatically stopping the action of pumps when irregularities of working occur or for giving indications thereof.

6,878. R. SCHMITZ. London. An improved electric alarm device for clocks.

6,893. J. V. DER POPPENBURG. London. An improved galvanic element with constant current, applicable especially for producing incandescent light.

May 5, 1890.

6,924. H. T. EAGAR and R. P. MILBURN. London. Improvements in electrical batteries.

6,939. W. H. CRAWCOUR. Nottingham. Improvements in connecting telegraph and telephone wires.

6,943. E. FISCHINGER. London. Improvements in electric arc lamps.

6,945. J. APPLETON. London. An improved electrical switch.

May 6, 1890.

6,959. B. MATTHEWMAN and E. D. PRIDE. London. For connecting electric globes or lamps to scarf pins, brooches, earrings, coronets, or any dress ornaments.

7,003. L. DUNCAN and H. H. CARPENTER. London. Electric motors.

May 7, 1890.

7,094. A. R. UPWARD. London. Application of electrical energy and self-acting switching mechanism to the purposes of advertisement.

7,132. H. H. LAKE. London. Improvements in the manufacture of carbon electrodes (Lacombe et Cie., France).

May 8, 1890.

7,185. W. P. THOMPSON. Liverpool. Improvements in welding metals electrically, and apparatus therefor (C. L. Coffin, United States).

SPECIFICATIONS PUBLISHED.

1889.

6,867. RICHARDSON and HILL. Incandescent electric lamps. (Price 8d.)

6,883. ATKINSON. Dynamos. (Price 8d.)

6,884. ATKINSON. Obtaining motive power. (Price 8d.)

6,885. ATKINSON. Obtaining motive power. (Price 8d.)

8,453. MORDEY. Electric currents. (Price 3d.)

9,166. WELLS. Electrical repeater. (Price 8d.)

9,571. KINGSBURY (Welles). Telephonic communication. (Price 8d.)

9,723. THE ELECTRICAL POWER STORAGE COMPANY (Limited), and REA. Secondary batteries. (Price 8d.)

10,155. RAWORTH. Electric tramcars, &c. (Price 8d.)

12,135. HEYS (Chaize and another). Electric cut-outs. (Price 6d.)

13,640. THOMPSON. Electric switches. (Price 8d.)

18,481. PAYEN. Electric batteries. (Price 8d.)

20,059. SMYTHE and PAYNE. Electrical "cut-outs." (Price 4d.)

7,774. Supplying electric current to road vehicles, &c. (Price 8d.)

9,182. GRAHAM. Telephonic circuits. (Price 11d.)

9,183. SUSSMAN. Electric batteries. (Price 4d.)

9,291. LAKE (Bradley). Dynamo electric machines. (1s. 1d.)

10,440. BAYLEY. Incandescent electric lamps. (Price 8d.)

10,556. GRAY. Electric cable. (Price 6d.)

10,699. SIEMENS BROTHERS and Co., Limited (Siemens and Halske). Electrical lamps. (Price 8d.)

11,049. WOOD. Dynamo-electric machines. (Price 1s. 1d.

19,129. BONNE (Meinecke). Electric batteries. Price 4d.

1890.

3,439. CURRIE. Secondary batteries. (Price 8d.)

3,717. WEIGERT. Galvanic batteries. (Price 4d.)

4,533. LAKE (The Thomson-Houston International Electric Company). Electric circuits. (Price 8d.)

4,557. ANDERSON and GIRDLESTONE. Dynamo electric machines. (Price 6d.)

4,407. MCGREW. Electric railways. (Price 8d.)

Second Edition.—1880.

3,880.* Disclaimer and Memorandum of Alteration of the Edison Electric Light Company, Limited (Jensen's Patent). Distribution of electricity. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

The Consolidated Telephone Construction and Maintenance Company (Limited).

The ninth annual ordinary general meeting of this Company was held at the Terminus Hotel, Cannon-street, yesterday. In the unavoidable absence of the Chairman, Mr. C. L. W. Fitzgerald, the chair was occupied by Sir Alexander Armstrong, K.C.B., &c.

The SECRETARY (Mr. Charles Curtoys) having read the notice convening the meeting,

The CHAIRMAN said he was sure, from the report in the hands of the shareholders, that they would consider that the affairs of the Company were in a very satisfactory state. They would perceive that the accounts showed a net profit of £12,714. 5s. 8d., which, with the amount carried forward from last year, left a balance of £14,272. 18s. for disposal, after making provision for doubtful debts. The Directors proposed to deal with this amount as follows: namely, to pay a further dividend of £7 per cent. for the half-year on the ordinary shares, and £6 per cent. on the Preference shares, making, with the interim dividend paid in November last, £6 per cent. for the year on both descriptions of shares, writing off the sum of £543. 3s. 8d. for depreciation of plant and machinery and furniture, and the sum of £2,000 for the Edison Gower-Bell Telephone Company's securities, leaving a balance of £1,842. 18s. to carry forward. During the year the Directors had received a further and final payment of £485. 16s. on account of the profit arising from the liquidation of the River Plate business, which concluded the Company's negotiations in that quarter, and which they must regard as a satisfactory settlement. They were aware, no doubt, of the action that was going on in Belgium with regard to the patent rights of the Edison Gower-Bell Company. He was sorry he was not in a position to give them any definite information as to its final issue. He would simply say that all the preliminary decisions had been in their favour—that was to say, in favour of the Edison Gower-Bell Company, with which their own Company was intimately allied. He thought it was not unlikely that a decision would be arrived at before the close of the year—that was to say, before the Long Vacation—for matters were now in such a forward state that the decision could not be long delayed. The subsidiary companies continued to make most satisfactory progress. He found that in Austria there had been an increase of 427 subscribers and of £2,512 rental. With regard to the Anglo-Portuguese Telephone Company there had been an increase of 202 subscribers and of £1,155 rental. They were all aware of the state of affairs in Portugal recently, and of the rather hostile feeling which existed with respect to every enterprise bearing an English name. Under these circumstances it might naturally have been thought that the Company's business would have consequently suffered largely. He was happy to say, however, that such had not been the case. During the year there had been a very steady progressive increase, which must be considered very encouraging under the circumstances. He hoped that when they next met they would have to report a still further steady advance in the business of the Company. With regard to the issue of the 10,000 Preference shares, he ought to mention that they had been taken up very rapidly, applications for considerably over the amount having been received. He looked forward to a still more hopeful future. He concluded by moving the adoption of the report and balance sheet.

Mr. H. GREWING seconded the resolution, which was carried unanimously.

In answer to Dr. HARDIE, Mr. J. G. GRIFFITHS, one of the Company's Auditors, said that the Company became originally interested in the Edison Gower-Bell Company by the acquisition of 174,995 shares in exchange for its patent rights. It subsequently purchased 20,000 Preferred and 15,000 ordinary shares, which were from time to time re-valued by the Directors, in accordance with their appreciation of their value.

The CHAIRMAN next proposed the re-election of the retiring Directors, Mr. C. L. W. Fitzgerald and Mr. Henry Grewing.

Mr. J. H. BUCKINGHAM, in seconding the motion, paid a warm tribute to the ability and painstaking care of both gentlemen in promoting the interests of the Company.

The motion was carried unanimously.

On the motion of the CHAIRMAN, seconded by Dr. HARDIE, Mr. Griffiths was re-appointed an auditor; as was also Mr. A. E. Green, on the motion of Mr. DAINES, seconded by Mr. GARDINER.

The motion was carried unanimously.

Mr. R. E. BATEMAN then proposed a cordial vote of thanks to the Chairman (Sir Alex. Armstrong) for presiding, the Directors, and the secretary; and begged to give expression on behalf of the shareholders to

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the sincere regret they all felt at the domestic bereavement which caused the absence of their Chairman, Mr. C. L. W. Fitzgerald.

This was carried unanimously.

The following report has been circulated amongst the shareholders:—

The accounts for the year ending the 31st March, 1890, show a net profit of £12,714. 5s. 8d., which, with the amount carried forward from last year, leaves a balance of £14,272. 18s. 0d. for disposal, after making provision for doubtful debts. The Directors propose to deal with this amount as follows, viz.: to pay a further dividend of £7 per cent. for the half-year on the ordinary shares, and £6 per cent. on the Preference shares, making, with the interim dividend paid in November last, £6 per cent. for the year on both descriptions of shares; writing off the sum of £543. 3s. 8d. for depreciation of plant, machinery, and furniture; and the sum of £2,000 from the Edison Gower-Bell Telephone Company's securities, thus leaving a balance of £1,842. 18s. 0d. to carry forward. During the year the Directors have received a further and final payment of £485. 16s. 0d. on account of profit arising from the liquidation of the River Plate business, which is included in the above statement. The Directors having deemed it in the interest of the shareholders that all parts of the telephone possible should be made in the factory, have lately built and fully equipped with machinery of a novel character, two workshops for manufacturing all the woodwork required. This has proved a great success. The action in Belgium, relating to the patents in which the Edison Gower-Bell Telephone Company is interested, is still in the hands of the experts; every effort has been used to hurry the matter on, but almost innumerable obstacles are placed in the way by our opponents.

The subsidiary companies continue to make most satisfactory progress, as is shown by the following statement:—

——	Year ending 31st March.					
	Subscribers.		Rental.		Increase.	
	1889.	1890	1889.	1890.	Subscribers	Rental
			£	£		£
Telephone Company of Austria	2,441	2,868	15,588	18,100	427	2,512
Anglo-Portuguese Telephone Company.....	1,713	1,915	11,077	12,232	202	1,155
Total increase for the year.....					629	3,667

In relation to the subsidiary companies, affairs in Portugal have caused your Board some anxiety, owing to the differences that have arisen between the two Governments. Matters, however, seem to be settling down in that quarter, and it is hoped that no harm will result.

Hastings and St. Leonard's-on-Sea Electric Light Company (Limited).

The annual general meeting of this Company was held on May 21st, at the office, Earl-street, Hastings; Mr. H. M. Baker, J.P., presiding. The notice convening the meeting, and minutes of the last meeting, were read and confirmed.

The annual report, which was taken as read, was as follows:—

"The Directors present herewith their statement of accounts for the year ended March 31, 1890. The revenue from lighting, rentals and fittings for the past year amounts to £2,561. 18s. 5d., as against £2,189 9s. 5d. for the year ended March 31, 1889, or an increase of £372. 9s. 0d. On the other hand, there has been an increase for the past year in wages, fuel, and hire of dynamo of £292. 1s. 0d.; the last item would have been still higher but for the purchase of the dynamo on favourable terms. The net profits, it will be seen, amount to £501. 8s. 1d., from which must be deducted the interest on mortgage and debentures, amounting to £280. 8s. 10d., leaving £220. 19s. 3d., which, added to £81. 11s. 8d. brought forward from last account, makes the sum available for dividend £302. 10s. 11d., out of which the Directors propose to pay a dividend of £3 per cent. free of income-tax, which will amount to £205, leaving a balance of £97. 0s. 11d. to be carried forward to the next account. Application has been made to the Board of Trade for a Provisional Order under the new Electric Lighting Act; and the Corporation, whilst applying also for powers under the same Act, have not opposed the application of the Company; and the Directors consider that it would be to the interest of the ratepayers if the whole of the lighting of the borough were undertaken either by the Company or by the Corporation. Captain Hennah, R.N., having resigned the office of secretary, the Directors have appointed Mr. Francis E. Burton to succeed him. Mr. F. Noakes and Mr. F. J. Parsons retire from the directorate by rotation; they are eligible, and offer themselves for re-election. The auditors, Messrs. Hart Brothers, Tibbetts, and Co., also retire, and offer themselves for re-election."

The CHAIRMAN, in moving the adoption of the report, said he had a communication from Mr. R. Hammond, a gentleman very largely interested in the Company; and as the letter was an important one, he would read it to them. It ran as follows:—"I am in receipt of the report and balance-sheet of your Company for the year ending 31st March, 1890, and, as a shareholder, I must congratulate the Directors upon the management of the business, which has been carried on with so small a plant with a result on the right side. I feel absolutely confident that if a good-sized plant were laid down in Hastings similar to that which has been laid down by the House-to-House Electric Light Company at Kensington, the economy arising from the larger machinery would lead to a very good financial result; and I must congratulate you and your colleagues upon having obtained the sanction of the Board of Trade to a Provisional Order giving your Company Parliamentary powers. I am confident that capitalists will be found ready to subscribe the necessary amount to lay down improved works, you having done so well your pioneer work." The Chairman pointed out that Mr. Hammond was largely interested in the Company, and had often assisted them in the working They would see that since their last meeting their Debentures had increased from £1,000 to £1,500, and these extra Debentures had been taken up by Mr. Hammond. At the time it had been of great assistance to them, and had had more than one beneficial effect. One of the benefits had been that it had enabled them to meet a demand of their bankers with reference to the interest of a mortgage held by them. There was another benefit, and that was that it had enabled them to execute some improvements in their boilers, the carrying out of which would be the means of greatly lesseuing the amount of fuel necessary; and he thought that their next balance-sheet would show a great saving had been effected in this respect. He believed in giving praise where it was due, and he thought that in their engineer they had a very valuable servant. The Chairman mentioned that, during the last year, the engineer had been offered a very lucrative position. He appealed to the Directors for their opinion on the matter, and they let him see that he was unfettered in this respect. After further considering the matter, however, he had decided to remain with them; and the Chairman hoped that the position of the Company would be such in the future that Mr. Mercer would not regret that he had not left. The Chairman then referred with satisfaction to the obtaining of their Provisional Order, by the increased powers granted to them under which he said they would be in a better position than before. He then mentioned the fact that the Town Council had at last arrived at the conviction that it was desirable to light the town by electricity, and expressed himself of opinion that the adoption of the electric light in the town would be a great advantage. With reference to the granting of their Provisional Order, he thought that they owed a great deal to the legal skill which Mr. Langham had exercised in the matter. He then referred to the fact that during the

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last eight years the Directors had had much anxious work; and although they had not had remuneration, still they were gratified, and, he might say, satisfied, with the success which the electric light had at last obtained in the town. He considered that at present their Company stood second to none of the provincial Electric Light Companies in the country. Alluding to the resignation of Captain Hennah from the office of secretary, the Chairman said that, like a true captain, he had not left the ship until it was in still waters. He thought that in Mr. Burton they would have a most efficient secretary. He had much pleasure in moving the adoption of the report, and the payment of a dividend of 3 per cent. Amongst the many adverse criticisms which they met with was that they had only declared a dividend on paper, but on that occasion that attack could not be made, for they now had the money, and the dividend would be paid at once.

Mr. BRAGG seconded the adoption of the Report.

Mr. BRAY asked whether the Town Council had been granted any powers by the Local Government Board for the supply of electric light to the town?

Mr. RODDIS said they had not, and he should very much doubt whether they would get it. He thought that if the ratepayers seemed to think that in widening the road along the Front the Council would be carrying out an extravagant work, it would be considered that they were extravagant in borrowing money for starting works for supplying the town with electric light.

Mr. LANGHAM thought that if the Council determined upon carrying out the work they were going to learn by experience, the same as that Company had done for the last eight years. He also considered that it would be very hard on the Company if, after these years of struggle, just as they were in a position to make their work a success, the Council should compete with them. He did not, however, think it would do the Company much harm, for they still had private lighting to depend upon. Mr. Langham pointed to the fact that the Board of Trade had endeavoured to make them reduce the scale of charges, but he had argued that it would not be fair to put this Company on a footing with those whose works were centred in very populous districts, and who supplied a large amount of light in a very small area. Owing to the straggling nature of their area of work they incurred a much larger expense in supplying the light, and by his representation of their position to the Board of Trade it had been decided that they should be allowed to charge the price stated in the Order as the maximum rate. They had now been able, by dint of great economy, to pay a dividend of 3 per cent., and they believed that, with additional capital, they would be able to supply more light with the same plant. They had all but one thing necessary for carrying on an extensive business, and that was the money which was needed to develop it. He thought that they were now in a position to appeal to the public, for theirs was an Electric Light Company which was able to pay a dividend, and he had no doubt that, with increased capital, they would be able to make the affair a great success.

The Report was unanimously adopted; and the retiring Directors (Messrs. Noakes and Parsons), and the auditors (Messrs. Hart Brothers, Tibbetts, and Co.) having been re-elected, the meeting terminated with a vote of thanks to the Chairman.

NEW COMPANIES REGISTERED.

GENERAL ELECTRIC POWER AND TRACTION COMPANY (LIMITED).—Objects: To carry on the business of manufacturers and contractors for the supply of electrical power of all kinds, adopting therefor agreements to be entered into with the Electric Traction Company, Limited, Moritz Immisch and Company, and the Electric Construction Corporation, Limited. The capital of the Company is £350,000, in £10 shares, whereof 10,000 are preference shares, with priority in return of capital to the holders of ordinary shares. Vote per ordinary share, and two votes for each preference share. First Directors (three to seven) to be appointed by subscribers. Qualification, fifty shares. Remuneration, £250 each (chairman £500). Borrowing limit, one-half of subscribed capital. Registered, May 22, by Ashurst, Morris, Crisp, and Co., solicitors, 6, Old Jewry, London.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this Company for the week ended May 23rd amounted to £4,617.

THE GENERAL ELECTRIC POWER AND TRACTION COMPANY (LIMITED).—The prospectus of this Company is issued announcing its formation with a capital of £350,000, in 10,000 £7 per Cent. Cumulative Preference shares of £10 each and 25,000 Ordinary shares of £10 each. The Preference shares are entitled, in addition to the cumulative preferential dividend of £7 per cent. per annum, to a contingent rateable division of profits with the Ordinary shares after payment of a non-cumulative dividend of £10 per cent. on the Ordinary shares. They are also entitled to priority in repayment of capital. The amounts payable on the shares are as follows:—10s. on application, £1. 10s. on allotment, £2 on September 1st next, and the balance in amounts of not more than £2 per share at intervals of not less than three months. The Company is established for the purpose of purchasing, amalgamating and developing the well-known businesses of the Electric Traction Company (Limited) and Messrs. Immisch and Co. The prospectus gives full particulars of the principal work recently accomplished or now in hand in these companies, and sets out in detail the various items which form the property of the new Company. This includes, in addition to the businesses already mentioned, a licence from the Electric Construction Corporation to use their patents for electric traction throughout the United Kingdom, and a contract upon the most favourable terms for the supply of their traction accumulators. Details are given in the prospectus of the electric launches fitted out by Messrs. Immisch upon the Thames, and also of those of the Traction Company running on the Union Canal for the visitors to the Edinburgh Exhibition, and also sets out a large number of mining and colliery plants laid down by Messrs. Immisch and Co. Of the capital issued, the whole of the Preference shares will be applied solely to the development of the business of the present Company. The full prospectus is set out on p. xiv. of our advertisements; and prospectuses, with forms of application for shares, may be obtained at the offices of the Company, 35, New Broad-street, E.C.; of the bankers, the London and Westminster Bank (Limited), Lothbury, E.C.; or of the solicitors, Messrs. Ashurst, Morris, Crisp, and Co., 6, Old Jewry, E.C. The secretary, *pro tem.*, is Mr. W. G. M. Mackenzie. A strong Board of Directors is associated with the Company, including Viscount Bury (Chairman), Lord Egerton of Tatton, Mr. Thomas Fuller, Mr. Moritz Immisch, Mr. James Paxman, Mr. James Pender, and Mr. Robert Macpherson (Managing Director).

NAMAQUA COPPER COMPANY (LIMITED).—At the ordinary general meeting of this Company, held on Wednesday, Mr. T. K. Weir, in seconding the motion for the adoption of the Directors' Report, alluded to the enormous increase of the consumption of copper in the United States, owing, in a very great measure, he believed, to the immense demand that had taken place for electrical purposes. He understood that for telegraph wires they now used copper instead of iron enormously. Telephones, too, were now to be found all over the country. A man who lived only a few miles from a station or town had his telephone; and he believed that had been, to an enormous extent, the backbone of the increase there. In this country, they might almost say that, as far as electricity was concerned, it had still not emerged from infancy; although there was a good demand for it, it did not compare with what had taken place in the States.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).—The numbers are announced of 76 Six per Cent. Mortgage Debentures, amounting to £7,600, drawn for repayment on and after June 30th, at the National Bank of Scotland (Limited), 37, Nicholas-lane, London, E.C.

STOCK EXCHANGE.—The Committee have ordered the undermentioned to be quoted in the Official List:—United River Plate Telephone Company (Limited), further issue of 3,000 shares, Nos. 55,001 to 58,000.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended May 15th show an increase of £58, as compared with the corresponding period.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended May 23rd, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,584.

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The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 21.		Price Wednesday, May 28.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending May 28.	
										Highest.	Lowest.
£			**TELEGRAPHS.**					£ s. d.			
1,381,390	Stock	12/6	Anglo-American	50	51	50	51	5 7 10	Jan., Apr., July, Oct.	..	..
2,809,310	Stock	25/0	Do. Preferred	86	87	86	87	6 6 5	" "	87	86½
2,809,310	Stock	..	Do. Deferred	15⅝	16⅛	15⅝	16⅛	..	February	15⅞	15⅝
250,000	£100	4%	African Direct, 4 per Cent. Debentures	98	101	98	101	3 19 3	January and July	100½	99½
130,000	10	3/0	Brazilian Submarine	11⅜	12⅛	11⅜	12⅛	6 2 5	Mar., June, Oct., Dec.	12⅛	11⅜
69,200	100	5%	Do. 5 per Cent. Bonds	101	103	101	103	4 17 1	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	106	109	106	109	4 11 9	June and December	..	..
16,000	10	9/0	Cuba Submarine	11	11½	11	11¼	7 16 6	February and August	11½	..
6,000	10	10%	Do. Preference 10%	17½	18½	17½	18½	5 8 1	" "	..	..
12,981	5	2/4½	Direct Spanish (£4 paid)	3⅜	4½	3⅜	4½	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 14 11	Jan., Apr., July, Oct.	10⅞	10½
400,000	10	2/6	Eastern	13½	14	13½	14	4 12 10	" "	13⅞	13½
70,900	10	6%	Do. 6 per Cent. Preference	14¼	15½	14¼	15½	3 18 8	" "	15⅛	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107	110	107	110	3 12 9	May and November	108½	107½
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	107	110	108	111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	13⅛	13⅜	13⅛	14	5 0 0	Jan., Apr., July, Oct.	13⅜	13⅛
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101	103	101	103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 per Cent. (Aust'n. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	" "	103⅜	..
180,227	10	2/0	Globe Telegraph and Trust	8⅜	8⅞	8⅜	8⅞	5 12 8	Jan., Apr., July, Oct.	8⅞	8⅜
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15	14⅜	15⅛	3 19 4	" "	14⅞	14⅜
150,000	10	5/0	Great Northern	15⅜	16	15⅜	16⅛	4 12 4	Jan., July, and April	15⅜	..
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102	105	102	105	4 15 3	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	38	40	38	40	6 5 0	April and October	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅜	8	7⅜	8	5 0 0	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	110	115	110	115	5 4 4	" "	114½	..
15,609	£10	3/6	West African	9	10	9	10	..	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	100½	99½
30,000	10	5/0	West Coast of America	5⅛	6⅛	5⅛	6⅛	7 13 10	January and July	5⅞	5⅜
150,000	100	8%	Do. Debentures 8%	117	122	115	120	6 13 4	June and December	..	..
88,321	10	Nil.	West India and Panama	2⅜	2⅝	2⅜	2⅝	..	..	2⅝	2⅜
34,563	10	12/0	Do. 1st Preference 6%	11	11½	11	11½	5 4 4	April and October	..	..
4,669	10	10/0	Do. 6 p. c. 2nd Pref.	12½	13½	12½	13½	..	..	12½	..
64,572	15	6/0	Western and Brazilian	9½	10½	9½	10½	..	May and November	10½	..
26,986	7½	6/0	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	6¾	..	..	6¾	6½
26,986	7½	7/6	Do. 5 per Cent. Deferred	3¾	4½	3¾	4	..	..	..	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	5%	Consolidated Telephone Const. and Maintenance	⅞	1⅛	⅞	1⅛	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	⅝	¾	⅝	¾	4 8 3	Yearly	..	..
386,875	5	3/0	National	5⅛	6⅛	5⅛	6⅛	..	June and December	6⅛	5⅜
49,825	5	..	Do. New	5⅛	6	5⅛	6	..	..	5⅛	5⅜
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference	12⅛	12⅝	12⅛	12⅝	4 14 1	June and December	12⅛	12⅛
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference	10⅛	10⅝	10⅛	10⅝	..	" "	..	..
209,750	1	..	South of England, Ordinary	⅛	..	⅛	..	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3⅛	3⅜	3⅛	3⅜	6 0 0	..	..	..
55,000	5	2/0	United River Plate	4⅛	5	4⅛	5	..	January and July	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅜	2⅝	2⅜	2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5	5⅛	5	5⅛	..	..	5⅛	..
42,853	5	..	Westminster Electric Supply	1⅞	2⅛	1⅞	2⅛	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅛	2⅜	2⅛	2⅜	..	..	2⅛	2⅛
63,416	2	1/2	Do. Preference	1⅝	1⅞	1⅞	2	6 0 0	..	1⅞	1⅞
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares	5⅛	5⅜	5⅛	5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..		..		..	..	..	..
409,000	10	..	Electric Construction	9⅜	10⅛	9⅜	10⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	4⅜	5⅛	4⅜	5⅛	..	..	5⅛	5
20,000	5	..	Fowler-Waring Cables	2⅛	2⅜	2⅛	2⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½	19½	19	20	..	February & August	19⅞	19
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5	5⅛	5⅛	5⅜	..	..	5⅛	5⅛
37,350	12	36/0	Telegraph Construction and Maintenance	44	46	44	46	5 3 11	March and July	45½	45
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	..	..	..

JABLOCHKOFF'S DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

The experiments of Mr. Kennelly, which we describe in another column, are deserving of close attention, as they were designed to make clear a part of magnetic theory which has hitherto received but little notice. Weber's theory of magnetism, as found modified in Maxwell's treatise, although, perhaps, the most generally accepted theory, and a most able contribution to magnetic literature, yet forms the least satisfactory chapter in Maxwell's book, and is quite out of keeping with the rest of the work. The assumptions made are arbitrary, and the adjustable constants introduced are so numerous that the mere agreement of the formulæ with the facts proves nothing. Permanent magnetism and hysteresis are partially accounted for, but no indication is given of any possible critical states of magnetism, such as are known to occur with iron; and it is in reference to these latter facts that Mr. Kennelly's suggestions are of value.

Consideration of the influence of molecular stress leads to the conclusion that the permeability at right angles to the lines of force should be greater than that in the direction of magnetisation; and this view was practically tested by measuring the inductance of a coil whose core was placed perpendicular to the lines passing between the poles of a large electro-magnet. The inductance of the coil for very small currents is a measure of the permeability required; and, as it is shown theoretically that with an isotropic medium this is the same as the permeability in the direction of the chief magnetisation, a comparison of the measured inductance of the coil with the permeability of the core, for the magnetism produced by the electro-magnet, indicated whether the iron could be regarded as isotropic or whether molecular actions were modifying the results.

The experiments were only partially successful; but some interesting results were obtained with wrought iron, for which the curves of inductance and permeability showed some marked divergences when the magnetising forces corresponded with certain critical stages in magnetisation, as, for instance, the Villari critical point. Having thus confirmed the idea that molecular stresses considerably modify magnetic phenomena, Mr. Kennelly sketches a theory, which, although it does not, like Maxwell's, lend itself readily to calculation, yet easily accounts for the character of most magnetic phenomena, and even for such a condition of instability as Prof. Ewing has recently called attention to, and of which no explanation has hitherto been offered. The theory is a modification of the ring theory of Prof. Hughes, and, though offering no explanation of the ultimate magnetism of molecules, simplifies matters by concentrating attention on lines of force. The molecular magnets arrange themselves in closed rings just as lines of force do, and an increasing magnetic force first distorts and ultimately disrupts the rings at a certain critical value. By attributing to the medium elastic and other properties, the result of this disruption may be made to resemble what happens in various kinds of magnetic bodies.

The recent annual meeting of the American Institute of Electrical Engineers was marked by a new departure in the shape of a visit to Boston, where the Papers, with one exception, were read. There is, perhaps, no better criterion of the solid progress which any industry has achieved than the number of technical Papers which are read at the various societies connected with it. In the early days of rapid development the numerous problems remaining to be solved give rise to animated discussions. But as soon as things begin to settle down into regular grooves the natural result is that the attention is diverted to some other branch more fruitful in interesting questions. Judging from the increasing number and importance of the electric traction Papers read at meetings such as that just held at Boston, and the comparative paucity of those on electric light, it would seem that this latter branch of the electrical industry in the United States is gradually becoming as crystallised as is, for instance, submarine telegraphy.

From the description we are able to publish this week it will be seen that Dr. Duncan's motor has the distinct advantage, so successfully shown in Mr. Mordey's dynamo, of having the moving parts of iron while the current-bearing coils are stationary. The field-magnets are indeed somewhat similar to those designed by Mr. Mordey for his well-known alternator, the difference being that the polar projections on one side are opposite the spaces between those on the other. The peculiar system of winding adopted will diminish sparking at the brushes, and the great number of poles and armature coils will render possible steady and efficient action at low speeds. These advantages are, however, purchased at the expense of great complexity of manufacture. A commutator of 420 segments divided into 28 groups is somewhat appalling.

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THE automatic principle, which has developed into something of a nuisance in this country, has been made use of across the Channel in a very characteristic manner. Listening to distant operatic and theatrical performances by means of the telephone has long been the vogue in Paris; and MM. MARINOVITCH and SZARVADY, who have devoted considerable attention to this branch of telephony, have now devised a very complete automatic system. Circuits connect the principal theatres and places of amusement to a central exchange, whence wires are run, or, rather, will be run, to the large hotels and clubs. Here "theatrophones" are installed, and by inserting the requisite coin in the proper receptacle anyone is placed in a position to enjoy as much of a performance as the condition of the apparatus, the state of the weather, and the length of his purse will permit. The approach of an *entr'acte* is automatically announced by the falling of an indicator over the "theatrophone," so that there is no need for money to be wasted. As the fee for a five minutes' "audition" is only 50 centimes, this method of listening to a performance is not very costly, when we consider its novelty and the saving of tissue it affords.

THE steady diminution of the copper stocks, which has now been taking place for some time past, has had its natural consequence in a steady rise of prices. This time last year—that is to say, three months after the collapse of the corner—copper was to be had for about £41 per ton; at the present moment the average price is close upon £55, a rise of over 34 per cent. Electric supply companies, especially those employing low-tension systems of distribution, will be the most affected by this state of things, owing to the impossibility of finding a suitable substitute for copper for their mains. Dynamo builders, the telephone companies, and the Post-Office, will, no doubt, regard this enhanced price with tolerable equanimity, owing to the variety of ways in which they can avoid being unduly hampered by dear copper, the experience they gained in this direction during the existence of the corner being considerable. Prices are still rising, though it is not very probable that copper will attain the prohibitive figure of £100 per ton, at which it stood at the end of 1888.

Stockton.—The Corporation have obtained the Provisional Order applied for by them.

The Cabanyes Battery.—*El Telegrafista Español* announces that the Cabanyes primary battery is to be used for lighting two rooms in the Royal Palace at Madrid.

Trient.—The streets of the old episcopal city of Trient are now lighted by electricity. Trient is the first city in Austria proper to adopt the electric light municipally.

The Yorkshire College, Leeds.—As will be seen by our advertisement columns, the post of demonstrator and assistant lecturer in physics at this college is now vacant.

Tabasco (Mexico).—This town, which has a population of 100,000, is to be lighted by 100 arc lights of 1,000 candle-power, for the sum of 10,000 pesetas (£400) per annum.

Moscow.—According to consular reports, progress at Moscow appears to have begun at the wrong end; both the electric light and the telephone are largely used, but the city is still without drainage or waterworks.

Magdeburg.—The want of an electrical testing station in North Germany has long been felt, and it has been decided to open one at Magdeburg, under the directorship of Dr. Martin Krieg, chief editor of the *Elektrotechnisches Echo*.

Bridlington.—At a special meeting of the Local Board last week, it was resolved, *nem. con.*, to accept the offer of Messrs. Laing, Wharton, and Down, to light the Princess-parade during the season with 7 arcs and 33 incandescents for £50.

Italian Duty on Accumulator Plates.—According to *l'Elettricità*, the Italian Custom House officials have decided that accumulator plates are to rank as parts of a dynamo, and must therefore pay a duty of 6 francs per quintal (1 cwt. approx.).

The Laurent-Cely Accumulator.—With reference to this accumulator, a brief description of which appeared in our last issue, we are informed that the English patent for the same was refused in January, 1889, by the Comptroller-General of the Patent Office.

Canterbury.—At an adjourned meeting of the Town Council on Wednesday last week, the electric light question was again considered; and it was unanimously decided on the recommendation of the Committee, that the Council should apply for a Provisional Order.

Wimbledon.—A public meeting of ratepayers has been called for the 12th inst. to hear their view of the electric lighting question. The Local Board, it will be remembered, decided last March to adopt the electric light in place of the present system of oil lighting.

Fire Alarm Experiments.—Some experiments took place at the Bradford Fire Brigade Station last week before several members of the Watch Committee, a number of manufacturers, insurance agents, and others, with an electrical alarm of the Automatic Heat Regulator and Fire Alarm Company, of Birmingham.

Electricity and Spiritualism.—At the forthcoming assembly of the London Spiritualistic Alliance, to be held on June 12th, at the Banqueting Hall, St. James's Hall, at 7:30 p.m., Mr. Desmond Fitzgerald, M.I.E.E., will deliver an address entitled "My Experiences in Spiritualism: a Word with Sceptics and Spiritualists."

The Telegraph in Burmah.—The telegraph line now being constructed from Chittagong to Burmah is, says *Indian Engineering*, making good progress. It is already laid on the east side to Haka, and on the west side to Fort Tregear. When the intervening space of some sixty miles only is completed there will be uninterrupted intercourse between Chittagong and Mandalay.

Earthquakes and Atmospheric Electricity.—At a recent meeting of the Japan Seismological Society in Tokio, Professor Milne showed from automatic records of atmospheric electricity that whenever there has been a severe shock of earthquake of which Tokio was at or near the *epicentrum*, the air suddenly has become negatively electrified, and has required several hours to return to its normal condition.

Kieff.—The British Vice-Consul has recently reported to the Foreign Office that there seems every prospect of the electric light being introduced at Kieff. The place, according to his report, is an ideal town for an electric light installation, the principal streets and public buildings being all within an area having a radius of less than a mile. The matter is, the Vice-Consul states, well worthy the attention of English companies.

Electricity and Microbes.—In a recent communication to the Académie des Sciences, MM. Apostolli and Laquerrière state that the general conclusion which they draw from recent researches is, that continuous currents of electricity, of the strength usually employed in electro-medical work, have no effect *sui generis* on microbes placed in a homogeneous medium, but that the destructive effects observed are due to the disengagement of acids and of oxygen.

The Boston Elevated Railway.—The Bill of the West End Street Railway Company to construct an elevated railway through the streets of Boston, U.S., is meeting with considerable opposition. The Bill contains a provision which permits the

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use of electricity as the motive power for the cars, and the West End Company contemplates the transfer of the street electric cars to the elevated track by means of an inclined plane.

The Copper Market.—The stock of copper in France, in England, and afloat has, according to Messrs. H. R. Merton and Co.'s statistics, fallen to 82,041 tons, compared with 90,230 tons at the end of April last, and 117,420 tons a year ago. The deliveries in France and England were extraordinarily large last month, being put at 17,030 tons, or fully three times the monthly average in the year of the Copper Syndicate (1888).

Personal.—Mr. Frank B. Lea, who has been the editor of our contemporary, *Electrical Plant*, almost since its initiation three years ago, has, we hear, severed his connection with that journal. Mr. Lea proposes to devote his attention to work of a more practical kind in the field of electric transmission of power; and we trust that his efforts in this direction will meet with the same success that characterised his journalistic labours.

Sheffield.—At a meeting last week of the Parliamentary Powers Committee of the Town Council the following resolution was moved and carried:—"That, considering the present position of the question of supplying electricity in large towns, and the probability of applications for power to do so in Sheffield being made by outside companies or persons, the Committee recommend the Council to adopt the needful steps for obtaining power themselves to supply electricity within the borough."

Paddington Vestry.—A Special Committee has been appointed to secure the insertion, in the Order of the Metropolitan Electric Supply Company now before the Board of Trade, of the various amendments agreed between the Vestry and the Company. A memorial signed by several members of the Vestry has also been sent to the President of the Board, calling attention to the "irregular procedure" of the Vestry, and requesting the Board of Trade, under the circumstances, not to grant the Order.

Edinburgh Exhibition.—A meeting of the London Committee of the Edinburgh Exhibition was held at the Mansion-house on Tuesday. Mr. Lee Bapty gave some particulars with regard to the progress of the Exhibition. The visitors in the first month had numbered 470,000, which was largely in excess of the most sanguine anticipations. If the same number of visitors continued each month until October, there would be a total of over four millions. The French electrical exhibits had, he stated, just arrived.

Dinner to Sir James Anderson.—On Wednesday evening a complimentary dinner was given to Sir James Anderson, at the Café Durand, Paris, to celebrate his birthday and the fiftieth anniversary of the date of his going to sea. Mr. Thomas Fuller presided, in the absence of Sir John Pender, and the representatives of most of the telegraph companies attended. An illuminated address was presented by Mr. Charles Burt, on behalf of the gentlemen who had signed it, in which reference was made to the services rendered by Sir James in connection with the laying and repair of submarine cables.

Lightning.—On April 8th, Louvain Cathedral was struck by lightning. One of the turrets was completely destroyed. The top, weighing about 4 tons, was projected a distance of 22 yards, demolishing a house, while blocks of stone weighing from 2 to 3 tons were hurled a distance of nearly 70 yards, damaging the houses in the neighbourhood.——During a recent sitting of the Berlin Town Council, says the *Elektrotechnischer Anzeiger*, the municipal buildings were struck by lightning. The discharge followed the electric light leads, shaking the lustre of the room in which the sitting was being held, and causing the incandescent lights to flare and blacken the glasses. No damage was done.

Institution of Civil Engineers.—The following particulars are taken from the report read at the annual general meeting of this Institution on Tuesday last. At the close of the past financial year the number of members was 5,872, and the gross receipts for the twelve months amounted to £22,478. Amongst the honorary members elected during the past year was Sir William Thomson. The Manby Premium was awarded to Messrs. W. P. James Fawcus and E. W. Cowan, who recently read a Paper on "The Keswick Water-power Electric Light Station," and a Miller Scholarship was awarded to Mr. C. Frewen Jenkin for an electrical Paper read at a supplemental students' meeting.

Helston.—An Art, Industrial, and Electrical Exhibition was recently held at Helston. The electrical exhibits comprised electrical apparatus and appliances shown by Mr. W. Slade Olver, jun., of Falmouth, and a large collection of telephonic apparatus lent by the Western Counties and South Wales Telephone Company. There were also lectures on the construction and use of telephones, by Mr. Olver, and telephonic concerts, transmitted over a mile of wire. Each evening the hall was lighted by electricity by Mr. Olver, the installation consisting of two 2,000 candle-power Gulcher arc lamps, two 500 candle-power Sunbeam lamps, and a large number of smaller incandescent lamps, driven by a large dynamo of the Gulcher type.

Fulham Vestry.—A special meeting of this Vestry was held last week for the purpose of considering the question of taking action to facilitate the introduction of the electric light into Fulham. The motion embodying this determination was carried by 32 to 20. Subsequently it was proposed that the House-to-House Electric Company should receive the consent of the Vestry to apply to the Board of Trade for a Provisional Order to supply not more than one-half of the parish with electric light, such area to be fixed by mutual arrangement, the Vestry's right to lay mains and supply electric light to any part of the parish at any time not to be prejudiced by such consent. The motion was lost, and the matter was ultimately referred to the Lighting Committee.

Presentation to Mr. Bernard Drake.—The staff and *employés* of Messrs. Drake and Gorham, who now number upwards of 80, presented Mr. Bernard Drake with a handsome plate chest, containing an assortment of silver plate, on the occasion of his marriage on May 28th. Mr. Drake, in thanking those who had subscribed towards this gift, said they all knew what importance he attached to an absolute unity of interests between employer and employed, and he should like to take that opportunity of thanking them all for the very loyal way in which they had always worked for the welfare of the firm. He liked them all to feel that as the business increased and prospered their individual interests were watched. Their object was, and always would be the same, viz., to do better work than anyone else, to employ better men, and pay better wages.

Obituary.—At the last meeting of the Académie des Sciences, M. A. Cornu gave a brief sketch of the life's work of M. Jacques-Louis Soret, who died on the 13th May. M. Soret was born at Geneva in June, 1827, and came to France at an early age, where he worked as one of Regnault's assistants. M. Soret at first devoted his attention to electrical research, and his study of the laws of electrolysis led him to define the conditions favourable for the production of ozone and to determine its density and chemical constitution. His investigations on the subject of the co-relation of physical forces contributed to the elucidation of the then obscure connection between electric currents, heat and mechanical energy. M. Soret also did classic work in other fields, such as optics, solar radiation and the seismic movements of the earth.

The Cuttriss Calculating Disc.—This calculating disc is an improved form of slide rule, by means of which a great variety of mathematical calculations can be performed. The instrument consists of a thin metal disc, round the circumference of which slides a ring of corresponding thickness, both the disc and the ring having scales engraved upon them. Two scales are engraved on the disc, and two on the ring, and by placing the scales in definite relative positions with each other, calculations can be readily performed, involving multiplication, division, proportion, vulgar and decimal fractions, powers, roots, and a large variety of problems. With a little practice and by the aid of simple constants many problems specially useful to electrical engineers may be rapidly worked out. The very portable and simple nature of this calculating disc seems to render it eminently suitable for use in outdoor work.

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Electric Lighting Provisional Orders.—The Board of Trade has granted Provisional Orders relating to Cambridge, Dover, Hove, Walsall, Wolverhampton, Worcester, Burnley, Bury, Chester, Fleetwood, Lancaster, Salford, Bacup, Bedford, Crompton, Huddersfield, Malvern, Oldham, Stockton-on Tees, Accrington, Barnsley, Blackpool, Burton-on-Trent, Cheltenham, Darlington, Bournemouth, Derby, Hastings and St. Leonards, Oxford, Portsmouth, Woking, Birkenhead, Great Yarmouth, Kingston-upon-Hull, Nottingham, Wigan, York, Belfast, Blackburn, Leicester, Morecambe, Sevenoaks, Tunstall, Ayr, Bognor, Eastbourne, Galway, Stafford, and Tiverton. Provisional Orders have also been granted for the following Metropolitan districts:—Lambeth, North London, St. James's, Westminster, St. George-the-Martyr, Southwark, and a portion of the parish of Camberwell, and Wandsworth. The Bills confirming these Orders now stand for second reading.

St. Pancras Vestry.—At a meeting of this Vestry last week Mr. Sweet moved that, in lieu of re-electing a joint committee of the Parliamentary and the Lighting Committees to carry out the work of electric lighting, a special committee be now appointed to carry out such work. That the special committee consist of eighteen members, to include representatives from each ward. That it be an instruction to the committee to report their transactions at the first meeting of the Vestry in each month. It was eventually decided to elect two members from each ward, with one extra from Wards 1 and 3, and the two churchwardens.—At the last meeting of the London County Council, the Finance Committee reported in favour of the application of the Vestry of St. Pancras for the advance of £10,000 to purchase a site for an electrical installation for the south-west portion of the parish. They recommended that the loan be granted on condition that it be taken up at once, interest being charged at the rate of 3½ per cent. and the principal being repaid by equal annual instalments within a period of 50 years. This was agreed to.

Annual Conference of the Postal Telegraph Clerks' Association.—On Saturday last the annual conference of this Association was held at Leicester, when about 60 delegates attended. In consequence of the Postmaster-General's insisting upon the presence of an official reporter, the names of the various speakers were suppressed. A resolution was adopted to the effect that, inasmuch as the Postmaster-General now states that he brought no charge against the Cardiff clerks, a request be sent to Mr. Raikes for their reinstatement. A proposal to affiliate the association with the Trades Council of the United Kingdom was referred to the district centres for consideration, and the Trades Councils were thanked for the services which they had rendered to the Association. A resolution was adopted thanking the Postmaster-General for having referred some of their demands to a departmental committee, but declining to accept the decisions of that committee as final. A long discussion took place on the action of the Postmaster-General in insisting on the presence of an official reporter at their meetings outside the Post Office buildings, and the course adopted by Mr. Raikes was strongly condemned.

The International Telegraph Conference.—A banquet was given on Friday last by the British Chamber of Commerce to the British and Colonial delegates to the International Telegraph Conference. Amongst those present were Messrs. Lamb, Fischer, and Benton, the British delegates; Messrs. Mallock and Brasher, the Indian delegates; Sir Graham Berry, Sir Arthur Blyth, Mr. Aylmer, and Sir Joseph Crowe, commercial attaché to the British Embassy here. On Monday afternoon the delegates to the Conference were entertained at luncheon at the Embassy by Lord Lytton. According to Reuter's telegram, Sir Francis Dillon Bell, Agent-General for New Zealand, is engaged in discussing with the French Government the advisability of reducing to a certain extent the cable rates between France and Australia. Similar proposals will be made by Sir Francis to the German delegates. Should France and Germany consider commercial intercourse with Australia important enough to enter upon a discussion of the matter now, rather than postpone it until the next Conference, five years hence, and should they be induced to share with Australia the risks involved by the reductions, Sir Francis Bell will submit the question for discussion to the Telegraph Conference. The Agents-General of the Australian Colonies have made application to the Secretary to the Colonies and the Chancellor of the Exchequer, asking for an appointment to discuss the reduced cable tariff scheme.

The "Peral" Electric Submarine Boat.—The "Peral" submarine torpedo boat, which is of the usual cigar shape, is provided with four screws, two vertical ones for effecting immersion, and two for purposes of propulsion. The screws are driven by Immisch motors run off specially constructed Julien accumulators, having a high output for weight. Matters have been so arranged that if any accident occurs to the motors and the immersion screws are stopped, the boat rises at once to the surface without further aid, though, of course, the emptying of the water compartments hastens the ascension. To avoid an undue expenditure of power in connection with the immersion screws, the water compartments are filled to an amount which enables a very slight motion of the screws to sink the boat to the required depth, and maintain it there. The automatic apparatus which regulates the depth at which the boat is to work is designed on a principle somewhat similar to that of the aneroid barometer. A curved tube of elliptical section is placed in connection with the sea, and its deformations due to the alterations of pressure actuate a switch, by which the strength of the current going to the immersion screws is varied. The positions of the contacts of the switch are altered to suit the particular depth at which it is required to work. A very sensitive automatic electrical device is also employed to keep the vessel in a horizontal position. The apparatus consists of a pendulum playing between two contacts. If the boat is not perfectly level from stem to stern, the pendulum touches one of the two contacts, and the result is that the corresponding vertical screw is actuated and the boat is righted. The speed which the inventor hoped to realise, namely, ten miles an hour, has been much exceeded.

Electrical Engineering at Columbia College.—In the April number of the *School of Mines Quarterly*, Mr. F. B. Crocker gives a brief description of the Electrical Department at Columbia College, and the following extracts may be of some interest. The facilities for obtaining electric current of different kinds and in large quantities are, he says, particularly satisfactory. Continuous current to the amount of 100 amperes under pressure of either 110 or 220 volts may be had at numerous points in all the rooms from a specially installed circuit of the three-wire system connected with the Edison 39th street station. Available at adjacent points and parallel to this circuit is another special circuit of equal capacity on the two-wire system coming from the Edison dynamos of 400 lights total capacity in the cellar. A third special circuit, also of 100 amperes capacity, has been put in to connect dynamos, motors, &c., in the electrical workshop down stairs with measuring instruments in the upper laboratory, which is devoted to delicate work. A storage battery circuit available at convenient points in the various rooms is to supply current under an E.M.F. of a few volts for testing purposes, galvanometer work, electrolysis and the many other duties which are generally performed in the laboratory by a number of separate primary batteries with their attendant inconveniences. The buildings are lighted entirely by electricity from the regular circuits. Gas for heating and other purposes may be had wherever needed from pipes fitted around the walls of each room just below the ceiling. The connection with the Manhattan Company's alternating circuit has lately been cut off by the city authorities, but alternating current and arc light dynamos are soon to be put in in order to avoid this unpleasant contingency. The students have just finished the construction, for experimental purposes in the laboratory, of a battery of 1,280 cells, which, when set up with Daniell elements, gives an E.M.F. of about 1,400 volts, and when set up as a storage battery, an E.M.F. of about 2,800 volts. Some interesting results have been obtained from the experiments performed with this battery. There has just been erected in the Mechanical Engineering Department a hydraulic testing-machine of 150,000 pounds capacity, and it is now to be used by the electrical engineering students for a series of tests which, it is expected, may be of considerable theoretical and practical interest in electrical science.

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ON THE PERMEABILITY OF IRON AT RIGHT ANGLES TO THE DIRECTION OF MAGNETISATION.

BY A. E. KENNELLY.

Weber's theory of magnetisation, in the modified form suggested by Clerk-Maxwell, is that which appears to meet with the most general acceptance; and it is a notable feature of this theory that it considers the restituting forces acting on the molecule to be a function only of their displacement angle, and to be independent of any mutual reactions between the molecules themselves during magnetisation, or of the influence which combination in polarity might exert upon the equilibrium of their intermolecular forces.

The intimate relations which have been found by so many observers to exist between the mechanical and magnetic conditions of iron in the mass, such for instance as its alteration in dimensions by magnetisation, the change of its magnetic properties under mechanical stress, the sounds emitted by iron bars under electromagnetic impulses, and the variations in the permeability of iron under varying temperatures, all suggest the *à priori* probability that the orientation of the molecules supposed to take place during magnetisation would call into play molecular reactionary forces of a mechanical or magnetic nature, whose effect upon the process would not be negligible, especially in advanced stages. It might be expected, in fact, that these molecular reactions would impede the progress of magnetisation to an extent increasing as that process was continued towards the maximum limit. Among the wide variations in magnetic behaviour exhibited by different specimens of iron differing sensibly in constitution, and the consequent latitude that a theory including all of them must possess, it would be difficult to detect the influence of any such reactions by direct calculation or comparison; but their effect would probably be to increase the apparent relative permeability of iron at right angles to the direction of magnetisation. That is to say, feeble magnetic forces brought to bear upon strongly magnetised iron would probably produce a greater magnetic displacement at right angles to the existing magnetisation than when co-incident with it in direction, owing to the expected absence of reactionary forces in the former line.

The experiments about to be described were made with the object of detecting any such difference of permeability if it existed. The results may be considered to have rendered a difference distinctly visible in the case of one sample of wrought iron, but with the specimens of cast iron and steel also tested, the conclusions are doubtful; for although the values obtained for their permeability are certainly greater than theory would warrant, they are not much more divergent than those obtained by the same method for their permeability in the direction of magnetisation itself.

While the success of the investigation has thus been only partial, the interest which attaches to the subject will perhaps be sufficient excuse for their complete presentation in condensed and tabular form.

The first experiments were made with a hollow cube of cast iron, 6 centimetres in length of edge. Two opposite sides of this box were wound with narrow coils of insulated copper wire passed in and out through slits suitably cut. By placing the box between the poles of a powerful electromagnet, the magnetic flux could be made to pass through one pair of coils and parallel to another pair. The electro-magnet was gradually excited, and the induction through the sides of the box measured by ballistic galvanometer, while the inductance of the coils across the flux was compared with that of the coils wound parallel to the flux by means of the secohmeter.

The measurements, several times repeated, all agreed in showing that the coils across the flux were most reduced in inductance as the flux itself increased—that is to say, the apparent permeability of the iron across the flux was the greater, the ratio being, in fact, about 2·5 to 1 at an induction of 11,000 C.-G.-S. line per square centimetre through the sides of the cube.

On closer examination, however, a serious source of error became evident that ought to have been foreseen at the first. The lines of force issuing from the coil parallel to the flux could not be confined to paths intersecting the flux at right angles; and the many stray lines round the ends of the coils, along the main path of induction, produced an error in the measurements too great to be neglected and too complex to calculate. The cube was therefore abandoned in favour of a more unexceptionable arrangement.

Four rings were then prepared, of practically equal dimensions and rectangular cross-section (Fig. 1), one of wood, the second of ordinary wrought iron, and the other two of cast iron and tool steel respectively. The particulars of their dimensions are given in Table I.

These rings were each wound with copper wire 0·036 centimetre diameter silk, covered to 0·046 centimetre in one complete layer of 289 turns, over oil-paper. The weight of this layer was 18·5 grammes, and its resistance 2·2 ohms at 22° C.

The inductance of these solenoids was then measured, with the results, in Table II., using a bridge, standard subdivided condenser, and secohmeter for reversals, by a modification of Clerk-Maxwell's method.

The somewhat low degree of precision in these measurements indicated by the probable error is due to the difficulty so often met with in measuring the inductance of coils surrounding soft iron, with feeble testing currents. The strength of the testing current in the above series was 29 milliamperes at the maximum steady value, from which H would be 0·53 in each coil.

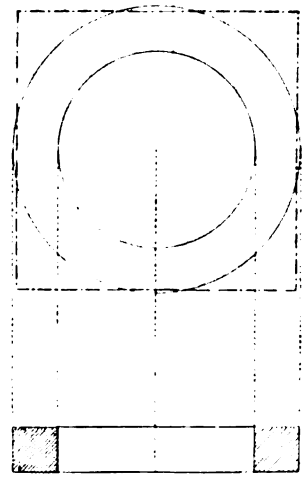

FIG. 1.—Iron Rings. Plan, and Diametral Section. Scale ½. Rectangle drawn — · — · — represents polar face.

The rings were then placed in succession symmetrically between the poles of the above-mentioned electro-magnet, so that the magnetic axis apparently coincided with the axis of the ring. The polar faces were planes 7·3 centimetres by 7·4 centimetres, and were kept apart 1·6 centimetres by corner wedges so as not to compress the ring. With the magnet unexcited, the inductance of the rings was found to be not sensibly altered by the presence of the iron poles; but on powerfully exciting the magnet, that of the three iron rings fell to quite a small percentage of its normal value, viz., wrought iron to 20 per cent., cast iron to 13·8 per cent., and tool steel to 25·4 per cent., the original values being restored on the cessation of the exciting current in the coils of the electro-magnet.

Steps were next taken to measure and control the amount of this magnetic flux across the ring, observing the inductance at each step. For this purpose five turns of fine insulated copper wire were wound on the external periphery of each ring, and five similar turns applied to the inner periphery by winding them on a closely fitted cork. The induction through these two windings at each stage of the magnetisation was measured in the usual way by electro-magnet reversal and ballistic galvanometer.

The difference between these inductions, slightly corrected for winding space occupied by the solenoidal coil, being the total flux through the ring normal to its plane, the mean value of the induction per square centimetre was immediately determined. The induction in the solenoid was similarly observed to make sure that no great error was involved by any want of accuracy in the alignment of the ring axis between the

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TABLE I.

Material of ring.	Internal diameter. Cms.	External diameter. Cms.	Depth of ring. Cms.	Mean diameter. Cms.	Cross sectional area. Square cms.	Volume by form. C.C.	Weight in air. Grammes.	Weight in water at 14°C. Grammes.	Volume by weight. C.C.	Specific gravity.
Wood	5·30	7·42	1·13	6·36	1·198	23·94	10·704	...	...	...
Wrought iron...	5·22	7·42	1·12	6·32	1·232	24·465	188·92	164·2	24·72	7·64
Cast iron	5·22	7·42	1·12	6·32	1·232	24·465	172·27	148·05	24·22	7·11
Tool steel	5·22	7·42	1·12	6·32	1·232	24·465	191·31	166·87	24·45	7·83

TABLE III.—TRANSVERSE MAGNETISATION OF WROUGHT IRON RING, BETWEEN POLES OF ELECTRO-MAGNET.

—	Source of E.M.F.	Temp. of cells C°.	E.M.F. at observed temp.	Capacity of condenser.	Q × 10⁷	No. of throws.	Mean throw.	Probable error of mean throw.	Value of one division in absolute quantity.	—	—	—	—	—
	2 Clark cells in series.	25·5 C°	Legal volts 2·853	0·409φ	1·167	8	Divs. 101·9	Divs. ± 0·17	1·145 × 10⁻⁹	...	...	...	...	...
I. No. of observation.	II. Current (amperes) exciting electro-magnet.	III. Divs. Mean throw of galvanometer from solenoid.	IV. Resistance of galvanometer cct. Average B round ring.	V. Divs. Mean throw of galvanometer from interior coil. Probable error of mean.	VI. Corrected φ, or induction corrected for winding space.	VII. Mean throw of galvanometer from exterior coil. Probable error of mean.	VIII. Resistance of galvanometer circuit.	IX. Corrected total induction, Φ, allowing for winding space.	X. Φ − φ, or total induction through iron.	XI. B, or transverse induction density through ring.	XII. Ratio of bridge.	XIII. Ohms. Resistance of solenoid and lead. Observed.	XIV. Micros. Capacity for balance with secohmeter.	XV. Inductance of solenoid. Kilometers.
1	0·089	3	25	0+	0	16·5+0·4	5250ω.	9,920	9,920	450	10000/1000 Temp Bridge 27·5 C.	4·559	0·400	182·4
2	0·1845	3	25	2·6+0·3	1,750	41·7+0·5	,,	24,710	22,960	1,050		4·554	0·400	182·2
3	0·44	7	59	6·3+0·5	4,240	104·2+0·5	,,	61,750	57,510	2,630		4·557	0·400	182·3
4	1·08	5	42	26·8+0·1	18,050	45·0+0	30,250	152,170	134,120	6,140		4·560	0·300	136·8
5	1·195	57	480	66·5+2·2	44,780	75·5+0	,,	252,250	207,470	9,500		4·568	0·080	36·5
6	3·51	83	700	76·3+0·3	51,380	93·5+0·2	,,	295,780	244,400	11,190		4·568	0·075	34·3
7	5·35	90	760	81·7+0·5	55,030	97·3+0·3	,,	325,630	270,600	12,390		4·573	0·075	34·3
8	11·59	86	730	93+0·8	62,640	109+0·4	,,	364,560	301,920	13,820		4·573	0·072	32·9
9	18·6	78	660	93+2·4	62,640	115±0	,,	385,460	322,820	14,780		4·620	0·071	32·8
10	0	...	...	...	...	...	...	...	...	...		4·620	0·480	221·8

Column IV. gives **B** determined from the equation $\mathbf{B} = \frac{5{\cdot}250 \times 10^{12} \times 1{\cdot}145 \times 10^{-9}}{2 \times 289 \times 1{\cdot}23} \times$ mean throw.

„ VI. „ ϕ „ „ „ „ $\phi = \frac{5{\cdot}25 \times 10^{12} \times 1{\cdot}145 \times 10^{-9} \times 1{\cdot}121}{1 \times 5} \times$ mean throw.

„ IX. „ Φ „ „ „ „ $\Phi = \left(\frac{5{\cdot}25 \times 10^{12} \times 1{\cdot}145 \times 10^{-9}}{2 \times 5} \times \text{mean throw}\right) - \frac{4{\cdot}42\phi}{21{\cdot}4}$

„ XI. „ **B** „ „ „ „ $\mathbf{B} = \frac{\Phi - \phi}{21{\cdot}85}$

The constant 1·145 is the absolute quantity per div. of throw.
289 „ number of turns in solenoid.
5 „ „ „ in external and internal coils.
1·12 „ correction factor for internal winding space.
4·42 „ area occupied by winding between iron and external coil.
21·4 „ internal area of iron ring.
21·85 „ plane area of iron in ring.

TABLE V.—TRANSVERSE MAGNETISATION OF TOOL STEEL RING BETWEEN POLES OF ELECTRO-MAGNET.

Source of E.M.F.	E.M.F. at observed temp., 22° C. Legal volts.	Capacity of condenser charged.	Quantity discharged through galvanometer.	Number of throws observed.	Mean throw. Probable error of mean throw.	Quantity per division of throw.	—
1 Clark cell.	1·430.	1·000.	1·43 × 10⁻⁷	7.	123·6.	1·157 × 10.⁻⁹	—

I. No. of observation.	II. Current exciting electro-magnet Amperes.	III. Mean throw of galvanometer from solenoid.	IV. Resistance of galvanometer circuit for solenoid and interior coil.	IV. Mean B round ring	V. Mean throw of galvanometer from interior coil. Probable error of mean.	VI. Corrected φ, or interior induction, corrected for winding space.	VII. Mean throw of galvanometer from exterior coil. Probable error of mean.	VIII. Resistance of galvanometer circuit.	IX. Corrected total induction Φ, allowing for winding space.	X. Φ − φ, or total induction through iron.	XI. B, or mean transverse induction density through ring.	XII. Ratio of bridge.	XIII. Resistance of solenoid and leads. Observed.	XIV. Capacity inserted for balance with secohmeter.	XV Inductance of solenoid. Kilometers.
1	0	...	...		...	...	...	5250	...			10000/1000	4·490	0·114	51·2
2	0·086	0	0		0	...	15·5+0·7	,,	9,410	9,410	430	...	4·490	0·113	50·7
3	0·115	7·5	5,250	64	6·7+0·3	4,560	48·4+0·3	,,	27,730	23,170	1,060	...	4·505	0·118	53·2
4	0·445	18		150	16·2+0·7	10,890	135·8+0·6	,,	78,470	67,580	3,100	...	4·505	0·108	48·7
5	0·985	73		620	39·7+1·0	27,020	333 +0·4	,,	192,410	165,390	7,570	...	4·495	missed	...
6	1·854	7		340	18 +0	70,560	93 +0·	30,250	299,670	229,210	10,500	...	4·463	0·073	32·6
7	3·38	7	30,250	340	21·8+1·0	85,480	114·5+0·4	,,	369,500	284,020	13,000	...	4·449	0·055	24·5
8	4·80	7		340	23 +0	90,190	121·5+0·4	,,	392,280	302,090	13,830	...	4·432	0·050	22·2
9	9·65	0		0	27 ±0·8	105,900	138· ±0·	,,	444,350	338,450	15,500	...	4·432	0·031	13·7
10	0	...	...		...	...	...	...	...	...	...	..	4·603	0·110	50·6

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TABLE II.

Ring.	Mean resistance of solenoid and leads. Observed & corrected for temperature.	Mean capacity inserted for balance with secohmeter.	Mean inductance of coil. Kilometers.	Probable error of mean result. Kilometers.	Number of observations made.	Percentage of probable error on inductance.	Ratio of bridge.	Temperature of bridge coils. Bridge correct at 19°.
Wood	2·27	0·041	0·9285	+0·0005	5	0·5	$\frac{1000}{10}$	27·3° C.
Wrought iron	2·28	0·734	167·5	±4·52	5	2·7	$\frac{10000}{1000}$	,,
Cast iron	2·32	0·230	53·4	±0·7	5	1·3	,,	,,
Tool steel	2·32	0·273	63·26	±1·7	5	2·6	,,	,,

TABLE IV.—TRANSVERSE MAGNETISATION OF CAST-IRON RING, BETWEEN POLES OF ELECTRO-MAGNET.

Source of E.M.F.	E.M.F. at observed temperature, 23° C.	Capacity of condenser charged.	Quantity discharged through galvanometer.	Number of throws observed.	Mean throw.	Probable error of mean throw.	Quantity represented by one division.	Time of observation.	Mean quantity per division of throw.	—
2 Clark cells in series.	2·858 L volts.	$0·409^{\phi}$	$1·169 \times 10^{-9}$	5	1·025	±0·1	$1·1405 \times 10^{-9}$	Before test	$1·141 \times 10^{-9}$	—
	2·858 ,, ,,	,,	,,	2	102·5	±0·4	$1·1405 \times 10^{-9}$	After test		

I. No. of observation	II. Current exciting electro-magnet. Amperes	III. Mean throw of galvanometer from solenoid.	IV. Resistance of galvanometer cct. Average B round ring.	V. Mean throw of galvanometer from interior coil. Probable error of mean.	VI. Corrected ϕ or interior induction, corrected for winding space.	VII. Mean throw of alvanometer from exterior coil. Probable error of mean.	VIII. Resistance of galvanometer circuit.	IX. Corrected total induction Φ allowing for winding space.	X. $\Phi - \phi$ or total induction through iron.	XI. B, or mean transverse induction density through ring.	XII. Ratio of bridge.	XIII. Resistance of solenoid and leads. Observed.	XIV. Capacity inserted for balance with secohmeter.	XV. Inductance of solenoid Kilometers.
1	0	...	...	...	...	...	5,250ω	...	...	...	$\frac{10000}{100}$	4·575	0·101	46·2
2	0·088	5	42	2 ±0	1,340	16 ±0	,,	9,300	7,960	365	...	4·639	0·099	45·9
3	0·112	1	8	3 ±0	2,010	17·5±0·4	,,	10,060	8,050	369	...	4·655	0·098	45·6
4	0·162	2	17	4·5±0	3,020	36 ±0·8	,,	20,940	17,920	820	...	4·651	0·097	45·1
5	0·30	5	42	9·5±0·8	6,380	73·5±1·2	,,	42,700	36,330	1,660	...	4·668	0 093	43·4
6	0·459	10	84	15·5±0·8	10,400	119 ±1·7	,,	69,080	58,680	2,690	...	4·666	0 091	42·5
7	1·11	13	109	34	22,810	44·3±0·5	30,250	148,190	125,380	5,740	...	4 690	0 070	32·8
8	2·63	32	270	58 ±0·8	38,810	77·7±0·3	,,	260,180	221,370	10,130	...	4·707	0·040	18·8
9	4·93	45	380	73	49,000	92·5±0·4	,,	309,080	260,080	11,940	...	4·707	0·038	17·9
10	20·7	57	479	94	62,890	109·5±0·4	,,	364,910	302,020	13,830	...	4·716	0 027	12 7
11	0	...	...	...	...	...	..	...	...	...	...	4·713	0·095	44·8

5250ω

TABLE VI.—MAGNETISATION OF RINGS SOLENOIDAL. THREE PRIMARIES IN SERIES.

Source of E.M.F.	E.M.F. at observed temperature, 22·5°C.	Capacity of condenser charged.	Quantity discharged through galvanometer.	Number of throws observed.	Mean throw.	Probable error of mean throw.	Quantity per division of throw.
2 Clark cells	Legal volts. 2·859	0·409 ϕ	$1·1695 \times 10^{-7}$	8	101·6	±0·2	$1·151 \times 10^{-9}$

I. Number of observation.	II. Ring tested.	III. Current in primaries - amperes.	IV. Magnetic force, H.	V. Mean throw from solenoid secondary. Probable error of mean.	VI. Resistance in galvanometer circuit.	VII. Inductionthrough iron ϕ.	VIII. Induction density through iron B.	IX. μ or $\frac{B}{H}$	X. κ or $\frac{\mu - 1}{4\pi}$.	XI. Ratio of bridge.	XII. Resistance of solenoid and leads. Observed.	XIII. Capacity inserted for balance with secohmeter.	XIV. Inductance. Kilometers.	XV. —
1	Wrought Iron.	0	...	...	...	...	...	...	...	$\frac{10000}{100}$	5·805	0·350	203	...
2		0·088	1·07	103·6+0·8	5,250	1,080	880	825	65	...	5·807	0·350	203	...
3		0·223	2·70	90·5+0·7	30,250	5,460	4,430	1,640	130	...	5·824	0·175	101·9	...
4		0·600	7·13	177·3±0·2	,,	10,680	8,670	1,216	97	...	5·834	0·140	81·7	...
5		1·11	13·4	66·1+0·5	105,250	13,850	11,240	840	67	...	5·844	0·090	52·6	...
6		2·73	33·0	84·3+0·3	,,	17,670	14,340	435	35	...	5·854	0·037	21·7	...
7		4·31	52·2	90·6±0·4	,,	18,970	15,400	295	23	...	5·980	0·025	14·8	...
8		10·03	121·4	98·5±0·4	,,	20,650	16,760	138	11	...	6·023	0·015	9·0	...
1	Cast Iron.	0	0	...	...	...	...	...	...	$\frac{10000}{100}$	5·877	0·056	32·8	...
2		0·088	1·06	6·8±0·3	5,250	71	58	54	4·3	...	5·855	0·056	32·8	...
3		0·223	2·69	19·7+0·3	,,	226	184	68	5·4	...	5·883	0·057	33·5	...
4		0·600	7·09	114·9+0·4	,,	1,200	976	138	10·9	...	5·838	missed	...	...
5		1·11	13·4	72·1+0·3	30,250	4,340	3,530	264	20·9	...	5·894	0·059	34·8	...
6		2·73	32·9	72·0+0·4	55,250	7,930	6,430	196	15·5	...	5·916	0·033	19·7	...
7		4·31	51·9	45·2+0·1	105,250	9,480	7,690	148	11·7	...	6·033	0·027	16·3	...
8		10·03	120·8	58·5+0·4	,,	12,260	9,950	82	6·5	...	6·300	0·017	10·7	...
1	Tool Steel.	0	0	...	...	...	...	...	...	$\frac{10000}{100}$	5·858	0·059	34·6	...
2		0·088	1·21	7·3+0·3	5,250	76	62	51	4	...	5·867	0 060	35·2	...
3		0·223	3·07	23·3+0·3	,,	244	198	64	5·1	...	5·877	0·065	38·2	...
4		0·60	8·12	117·5±0·4	,,	1,230	998	130	10	..	5·838	0·061	35·6	...
5		1·11	15·3	115·8+0·6	30,250	6,980	5,660	370	29	...	5·901	0·073	43·1	...
6		2·73	37·6	121·7+0·9	55,250	13,390	10,880	290	23	...	5·929	0·035	20·7	...
7		4·31	59·4	73 +0	105,250	15,300	12,420	209	17	...	6·040	0·026	15·7	...
8		10·03	138·2	88 +0·8	,,	18,440	14,970	108	8·5	...	6·410	0·014	9·0	...

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poles, this induction being, of course, with perfect alignment equal to that through one turn round the external periphery.

The results obtained in this way with each iron ring are given in Tables III, IV., V.

The exterior and interior turns were next removed, and a primary solenoidal winding of cotton-covered wire laid on each ring over the original layer now used as a secondary. This done, the rings were magnetised in the usual circular manner by measured currents through the primary coil, while the corresponding induction through and inductance of the secondary layer were observed at each step. This determined the inductance of the coil corresponding to each value of the magnetising force and circular induction per square centimetre. The results with each ring are given in Table VI.

(To be continued.)

THE WIRING OF HOUSES FOR THE ELECTRIC LIGHT.

BY E. C. DE SEGUNDO, ASSOC.M.INST.C.E.

To those whose lot has been cast among "pioneering" electric light ventures, and who have been connected with electric light companies from the time of their formation, it will be apparent that perhaps the one thing which has militated against the extension of electric lighting amongst private consumers more than another has been the large first cost of installing a house with the necessary wires. Another cause is the endless dissension which has arisen from time to time between supply companies and contractors as to the lines on which a house should be wired, unnecessarily complex safety precautions being frequently insisted upon. It is a good fault, no doubt, "to err rather on the right side;" but, in the face of the experience which has been gained in the fixing and maintenance of electric light wires, there should be no longer any necessity to err at all, whether on the right or on the wrong side.

To encourage competition is very right and proper; but it is possible to carry this principle too far in order to get rid of personal responsibility. If A manufactures a better article than B at the same price there should be no hesitation among those whose duty it is to discriminate, to pronounce in favour of A unequivocally. If A's article at price x is better than B's article at $(x-a)$, (where a is a positive quantity), it is quite possible that the ratio $\frac{\text{quality of A's article}}{x}$ may be numerically equal to $\frac{\text{quality of B's article}}{x-a}$, and, within certain limitations, there might be no reason why A should be recommended rather than B. If, however, the use of B's article involves so great an element of risk or danger as to render its introduction unadvisable, there can, of course, be only one opinion of the authority who favours B. A great many of the incidents which have tended to hamper the progress of, and throw discredit on, electrotechnics here as well as in the States, have been due to B's article having been specified—for a consideration—where A's should have been used; and there cannot be the shadow of a doubt that if electric lighting is to make rapid and honourable progress, consulting engineers and supply companies should lose no time in deciding whether they will tolerate the use of B's article when A's should be used; and should make a firm stand, insisting upon work being done as they know it should be done, and not allowing themselves to be swayed in any direction by the expressions of opinion of interested parties.

It is impossible to read any of the rules drawn up by insurance companies without feeling that the compiler is unwilling to commit himself to any unequivocal expression of opinion; the saving clause, "in special cases the work is to be done to the satisfaction of the inspector," is frequently met with at the close of a paragraph. One is naturally led to ask, what constitutes a special case? For surely that is very much a matter of opinion; it would seem more reasonable to specify that in cases of differences of opinion, as to what is safe and what is not safe, the matter should be referred to competent arbitration.

As an instance of the unsatisfactory nature of some of the specifications in the schedules issued by supply companies, take the allowable intensity of current according to some of the supply companies' specifications. It is 1,000 amperes to the square inch. This stipulation seems to be of a somewhat apologetic nature. It allows the greatest possible benefit to the installer and the least possible—consistent with the fear of complaints as to the intensity of the light in various parts of the house—to the consumer. The installer as a rule is not so overburdened with cash as to be able to afford to quixotically put more copper in the mains than he is obliged to; the consumer, on the other hand, is usually a man by whom a few pounds more for copper would not be grudged, if the advantages were made plain to him; the supply companies, if their interests alone were considered, would specify 100 amperes to the square inch in the houses, or other parts of the distributing system they don't pay for, in order to save coal.

The 1,000 amperes specification seems to be an attempt to please all parties concerned, as far as possible; but it is obvious that in a large house anything like 1,000 amperes per square inch at full load would cause an appreciable drop in the furthest lamps. Of course, no good firm of installers wires at an intensity of over 600 amperes per square inch at full load for any distance; but at present the demand is so large compared to the supply that the numerous contracts run away with by small and untrustworthy firms are not noticed in the crowd. These small and inefficiently performed contracts, however, do not tend to add to the reputation of electric lighting in the estimation of the general public. The consumer who had paid for the wiring of his house under the conditions of "best workmanship" and "best materials," naturally turns to the supply company to remedy the 5 per cent. drop in his bedroom lamps. The company send up their representative to test, and discover the true state of affairs. This cannot be appreciated by the consumer, who is, naturally, in nine cases out of ten, not a technical man; and then begins the wrangle between contractors, consumer, and supply company. The contractors maintain that 1,000 amperes is allowed by the supply company; and so the unfortunate consumer finds himself in a difficult position, inasmuch as he is mixed up in a dispute on a matter that he does not in the least understand. It does not mend matters in the slightest to urge upon the consumer that electric lighting, *per se*, is not to blame, and to attempt to demonstrate the philosophic axiom that all things are good, the abuse of them only constituting evil; he does not wish to see the matter in that light, and does not hesitate to express his views to his friends as to his practical experience of electric lighting.

Obviously, not only is it advisable in the interests of electric lighting, but it is necessary in the interests of the consumer and the company, that the 1,000 amperes per square inch specification should be qualified by a maximum permissible difference of percentage of drop in the potential at the terminals of the furthest lamp, at light-load and full-load. If these conditions were fulfilled the company would feel sure that consumers would be receiving from their lamp the proper intensity of light as long as the potential in the supply mains was up to standard. They would further be able to judge with more accuracy the efficiency of their system, as they would then know the maximum loss to be allowed for each house supplied. The only party likely to object to this is the cheap contractor, the man who will undertake to put in the best work, the best materials, the latest improvements, &c., for 18s. a light.

The question of allowable current intensity is, of course, only one of a large number which have to be considered, and there can be little doubt that there is plenty of need for consideration and reconsideration in these matters. Supply companies would do well to realise more fully, or perhaps we should say, act as if they realised the great importance to them of sparing no pains to counteract the growing idea that having the electric light in one's house necessarily entails a great deal of worry, and annoyance, and possibly litigation. Early supply companies have done much to hamper the extension of electric lighting by their disregard of the annoyance to which their con-

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sumers were subjected owing to "steam getting low," machine No. so-and-so breaking down, and kindred occurrences which should never, and would never have happened if so important a matter as the control of the plant for the supply of light to private consumers had been placed in the hands of reliable men, and not relegated to mere boys whose ideas of duty were somewhat limited, and who seemed to in no way appreciate the grave responsibilities they incurred in virtue of their position. There can be little doubt that what applies in commerce applies also in electric lighting, namely, that the firm which treats its customers best will in the end be the most successful, and thus there can be little fear of contradiction if it is asserted that the greatest discretion should be exercised in the choice of a superintendent for an electric lighting centre, and that the supply companies' specification for the wiring of houses to receive current should be revised with a view to the protection of themselves and their non-technical clients.

The following suggestions are put forward in no dogmatic spirit, but merely as an attempt to point out in what direction reform might usefully take place. It is not intended to lay down such complete and detailed instructions as shall apply to every possible case.

Questions connected with unusual circumstances which call for unusual precautions must, of course, be left to the authority who is responsible for the general character of the work; and, indeed, it would be idle to attempt to frame so complete a code of laws as would in themselves constitute an all-sufficient source of reference; but there can be no doubt that in one or two important details the requirements in the specifications of supply companies and insurance offices could well afford to be made more definite. One has already been mentioned, namely, the question of intensity of current allowable in the conductors. This is contained in Section 2 of the "Phœnix Rules." It is stated, first, that "all conductors are to have sufficient sectional area to allow at least 100 per cent. more electricity being safely sent through them than will ever possibly be required for the lights they supply." Then comes a sub-section, "Under normal conditions for internal work the ratio, 1,000 amperes per sectional square inch of copper, is a fair proportionate quantity of current to send through a conductor when the amount passing through the said conductor does not exceed 100 amperes." The portion quoted leaves one in doubt as to whether—(*a*) 1,000 amperes per square inch, &c., is the allowable intensity when the 100 per cent. extra permissible current is considered to be flowing; if not, (*b*) does "normal" refer to the conditions in every-day work? if so, (*c*) what conditions are to be considered normal? for the load varies with the weather and the time of day or night.

The specified allowable current density per square inch of cross section of conductor should, as before remarked, have regard to the loss due to the resistance of the conductor. It is naturally also necessary to specify a maximum current density, as in the case of short lengths the allowable percentage of loss would not be a sufficient protection. The section governing the intensity of current conductors might be worded somewhat as follows:—

(i.) The current density is in no case to exceed 1,000 amperes per square inch of cross sectional area of a solid conductor of copper containing the same volume of metal per unit of length as the conductor in question. The copper used to be of at least 96 per cent. conductivity. The system of conductors to be so designed that the drop in potential at the terminals of any lamp when at maximum load shall not exceed 2 per cent. of the potential at the point where the current enters the house from the source of supply, whether this be the supply mains of a company or any other source of electrical pressure.

(ii.) The maximum load to be stated by the consumer in terms of the number of watts which he will require.

Another point in regard to which some discussion might be fruitful of good result is the question of fuses. In regard to this matter there is, perhaps, no question in house-wiring on which the adage, "Prevention is better than cure," bears more closely. The practice of using inferior material and then sowing fuses broadcast cannot be too strongly condemned. It is evident that inasmuch as the function of a fuse is to cut off the current supply when the current density becomes so great as to be liable to cause undue heating at any point, it is necessary that in the case of a branch system from any main or sub-main the smallest wire should be efficiently protected.

Thus, if the size of the smallest wire be first determined, the position of the first necessary fuse will be found by working back towards the main. It will be at that point where the current intensity required for the various lamps "picked up" on the way becomes from 75 to 80 per cent. of that which the smallest wire can bear without injury. Now, it is clear that under these restrictions a system of conductors might obtain in which the smallest conductor was of such a size that in the event of a partial short-circuit the fuse would allow enough current to pass to maintain a small arc sufficient to set any inflammable matter near the short circuit on fire. Clearly, then, provision must be made for the circuits to be so divided that none will carry a current whose value would ever exceed a safe one before the fuse blew. In the case, for instance, of the gradual breakdown of insulation at any point and the gradual increasing short circuit or earth, the fuse should blow and cut off the current before the leak becomes dangerous. Then, of course, the question arises, what constitutes a dangerous leak? That is a matter which will probably always remain a matter of opinion. Theoretically it would be wise to divide the house to be lighted into sections and lead conductors for each section to a distributing fuse board whence separate leads would be taken off through a suitable fuse for every lamp or group of lamps controlled by a single switch. This, it is asserted, would involve a heavy expenditure; but perhaps when the decrease in cost, owing to the time saved in making joints and the saving due to the fact that conductors of less insulation resistance can be employed, is set off against the increase of cost due to the greater length of conductor used, the difference will not really be so great.

A short circuit can easily be prevented from becoming dangerous by the interposition of suitable fuses. An "earth" is much more difficult to deal with, inasmuch as its "degree" varies with the weather, the state of the building, its capacity for absorbing moisture, and all circumstances which affect the insulation of the leads. Moreover, the real potential difference between either lead or any particular point in either lead and the earth must be more or less a matter of conjecture; hence the intensity of the leak becomes also indeterminate. Obviously it would be unwise to attempt to control the amount of leak to earth by means of fuses used in the ordinary manner; and it appears probable that the only satisfactory way to guard against possible dangers from any earth on the circuit becoming dangerous is frequent testing.

The question of fuses might be dealt with in somewhat the following manner:—"A double-pole fuse to be inserted between a main and a branch wherever the change of section is such that the smaller conductor is not capable of carrying, without risk of injury, the maximum current which the fuse controlling the main will allow to flow, the size of the smaller conductor being conditioned by the number of lamps it has to feed and the allowable percentage of fall of potential difference. Tests of insulation resistance to be made at regular and frequent intervals by a competent electrician, any gradual lowering of the insulation resistance beyond that which might be expected, owing to extraneous conditions (weather, temperature, &c.), to be reported and investigated without delay."

Generally, it might be said that the safest and best principle to go on is to put in work of such quality and workmanship that it may be relied on to protect itself, so to speak, and thus obviate the necessity of placing so much dependence on fuses, particularly as, in the hands of technically uneducated people, fuses become a fruitful source of danger, and as the breaks in the continuity of the casing due to the interposition of many fuses tends to lower the insulation resistance of a circuit. It might, perhaps, not be out of place, in conclusion, to emphasise the advisability of surface work as far as practicable, and to recommend that if surface work is objected to on the ground of unsightliness, it would be wiser to move in the direction of cheapening ornamental casing rather than to hide it between floors and in plaster. There is no reason, for instance, why the moulding at the top of a high dado should not be constructed to receive leads.

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THE TREATMENT, REGULATION, AND CONTROL OF ELECTRIC SUPPLY BY THE LEGISLATURE AND THE BOARD OF TRADE.*

BY MAJOR P. CARDEW, R.E.

Mr. President and Gentlemen: Before starting with the undertaking which in a moment of weakness I have laid upon myself, I have to ask a favour and convey a warning. The favour is, that you will bear in mind that nothing I may say to-night possesses any official sanction, or can be taken as in any way expressing the views of the Board of Trade. Before preparing the Paper I obtained permission from the Department under which I serve to do so; but some rather delicate ground is traversed in the Paper, and I am sure I may rely upon your forbearance to-night in any discussion which may arise to avoid any questions of policy. The warning is, that I am painfully conscious that the Paper is very dry and portentously long.

The subject which I have the honour to submit to your notice to-night is "The Treatment, Regulation, and Control of Electric Supply by the Legislature and the Board of Trade." I am afraid the scientific interest of the Paper is very small; but as many of you are practically concerned in the matters dealt with, I hope it will not be considered to be out of place.

The first attempt to deal with the question of electric supply on the part of the Legislature was the Act of 1882. As notice had been given of many private Bills to be brought in to acquire the necessary powers for a general supply, proceeding on very varying lines, it was thought that the time had come for a general Act dealing with the subject. The two principal objects of this Act were—(1) To empower electric supply companies, or persons, or Local Authorities desirous of undertaking this supply for their own districts, to lay their mains in the public streets, and conduct the business of supply generally in a manner recognised by law; (2) to recover charges for supply made to consumers. At the same time proper regulations and conditions were imposed upon the undertakers to secure the safety of the public and the adequacy of the supply; while the fear of creating a new perpetual monopoly was evidently present in the minds of the framers of the Act.

This Act is so familiar that a short sketch of its provisions will be sufficient. It sets out by detailing the various ways in which statutory powers can be obtained. These are—(1) By licence, (2) by Provisional Order, (3) by special Act.

The issue of licences is left entirely in the hands of the Board of Trade, but the consent of every Local Authority affected must first be obtained. The original period for which a licence is granted must not exceed seven years, but it may be renewed with the like consents. A licence may be for "public purposes" or "private purposes." "Public purposes" only allows supply for electric lighting of streets, public places, buildings, theatres, &c.; while "private purposes" allows general supply, not only for lighting, but for any other purpose, except the transmission of any telegram. The Board of Trade is empowered to make such regulations and conditions in a licence as it may think expedient.

Provisional Orders in this Act may be granted without requiring the previous consent of the Local Authorities affected, but have no force unless and until confirmed by Act of Parliament. The period of an Order may be limited or it may be unlimited in duration. There appears to be very generally diffused a mistaken idea on this point. Many people appear to think that a Provisional Order only lasts for 42 years, or 21 years under the old Act. This was stated in *The Times* the other day as a fact. It is, however, quite a mistake. The Orders granted by the Board of Trade, and confirmed by Parliament, have hitherto been, without exception, I think, unlimited in duration. There are various provisions for sale or transfer of the undertaking, including, in the case of a company, compulsory sale to the Local Authority; but these provisions may never be acted upon, and even if they are put in force do not extinguish the powers granted.

Section 6, with respect to regulations, is so important that it will be better to read the exact words—

6. *Regulations to be inserted in licences, &c.*—The undertakers shall be subject to such regulations and conditions as may be inserted in any licence, Order, or special Act affecting their undertaking with regard to the following matters:—

(*a.*) The limits within which and the conditions under which a supply of electricity is to be compulsory or permissive;

(*b.*) The securing a regular and efficient supply of electricity;

(*c.*) The securing the safety of the public from personal injury, or from fire or otherwise;

(*d.*) The limitation of the prices to be charged in respect of the supply of electricity;

(*e.*) The authorising inspection and inquiry from time to time by the Board of Trade and the Local Authority;

(*f.*) The enforcement of the due performance of the duties of the undertakers in relation to the supply of electricity by the imposition of penalties or otherwise, and the revocation of the licence, Order, or special Act where the undertakers have, in the opinion of the Board of Trade, practically failed to carry the powers granted to them into effect within a reasonable time, or discontinued the exercise of such powers; and

(*g.*) Generally with regard to any other matters in connection with the undertakings.

Provided always that the Board of Trade may, from time to time, make such regulations as they may think expedient for securing the safety of the public from personal injury or from fire or otherwise, and may from time to time amend or repeal any regulations which may be contained in any such licence, Order, or special Act in relation thereto; and any regulations so made or amended by the Board of Trade shall, from and after the date thereof, have the like effect in every respect as though they had been originally inserted in the licence, Order, or special Act authorising the undertaking; and every regulation so repealed shall, from and after the date thereof, be repealed accordingly, but such repeal shall not affect any liability or penalty incurred in respect thereof prior to the date of such repeal, or any proceeding or remedy which might have been had in relation thereto.

Any Local Authority within any part of whose district electricity is authorised to be supplied under any licence, Order, or special Act, may, in addition to any regulations which may be made under the preceding provisions of this section for securing the safety of the public, from time to time make, rescind, alter, or repeal bye-laws for further securing such safety; and there may be annexed to any breach of such bye-laws such penalties, to be recovered in a summary manner, as they may think necessary: Provided always, that no such bye-laws shall have any force or effect unless and until they have been confirmed by the Board of Trade and published in such manner as the Board of Trade may direct.

The proviso enabling the Board of Trade to make regulations from time to time, and to amend or repeal any regulations, is certainly a wise provision, and, as you are aware, it has been largely carried into effect. The power conferred upon the Local Authority of making bye-laws for further securing the safety of the public should also be noted, and that this may be exercised even where they are themselves the undertakers. In the case of Local Authorities being undertakers, power is given for them to contract for the execution and maintenance of any works, or for the whole business of supply; but they are forbidden to transfer or divest themselves of any legal powers or liabilities without the consent of the Board of Trade. As regards overhead wires, undertakers must get the express consent of the Local Authority for their erection along, over, or across any street, and the Local Authority may remove any electric line placed above ground without such consent, and, even where such consent has been given, a court of summary jurisdiction may order the removal of any electric line on the ground of public safety. It must be noticed, however, that nothing in this Act empowers any interference on the part of the Board of Trade or any other authority with electric lines erected by persons who are not undertakers. The undertakers are not allowed to prescribe any special form of lamp, or to interfere with the use made by any consumer of the supply given to him; but no consumer is to deal with his supply in such a manner as to unduly or improperly interfere with the supply to other consumers; and any dispute as to this may be be determined by arbitration. There are provisions against undue preference on the part of the undertakers in their supply and charges. I take the meaning of these sections (19) and (20) to be this—that the undertakers may make any agreement as regards price, hours of supply, &c., provided that the price is not in excess of the maximum rates laid down; but that, where they have made any such agreement with any private consumer, any other private consumer may demand a similar agreement, where the conditions are similar. And so in the case of street-lighting authorities; but not that a private consumer could demand to be supplied at the same rate as is agreed upon for the street lighting or for lighting a large theatre. Supply may be cut off for neglect of payment of charges due, but only until these charges and any expenses incurred in cutting off the supply are fully paid. Any unlawful and malicious injury of electric lines and works is made a felony, and any person who maliciously or fraudulently abstracts, causes to be wasted or diverted, consumes or uses, electric energy is declared to be guilty of simple larceny—in fact, to have stolen it. The purposes for which the officers of the undertakers may enter premises of consumers are strictly defined, and they have no legal right of entry for any other purpose—*e.g.*, to inspect the electric lines and fittings of the consumer. The Board of Trade has, however, so framed the Orders and Safety Regulations as to make it unlikely that any consumer would refuse entry to a properly authorised agent of the undertakers, if required by them to make an inspection of these electric lines and fittings. In the section of the Act providing for the protection of the Postmaster-General, it is curious to note that a distance of 10 yards was apparently considered as the outside limit of distance within which a telegraph line might be affected by an electric supply line.

The section dealing with compulsory purchase by the Local Authority after 21 years has been made the scapegoat for the failure of the electric lighting "boom" of 1883. It is questionable, however, whether it had so much effect as is attributed to it

* Paper read at the Institution of Electrical Engineers, on May 15, 1890.

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in preventing capitalists from coming forward to support electric lighting schemes, and also whether whatever checking influence was really due to it has not in the long run been as beneficial as a nipping frost in early spring in restraining youthful impetuosity. And I may remark that this clause did not excite any serious opposition at the time; in fact, the Bill was sent up from the Commons with a fifteen years' limit, and extended in the Lords to 21 years, which was considered an ample time even by the persons best qualified to judge, as is amply demonstrated in the minutes of evidence given before the Parliamentary Committee.

In the amending Act of 1888 the first section has two important provisions:—

1. *Consent of Local Authority generally required to Provisional Order for Supply of Electricity.*—Notwithstanding anything in the Electric Lighting Act, 1882, no Provisional Order authorising the supply of electricity by any undertakers within the district of any Local Authority shall be granted by the Board of Trade except with the consent of such Local Authority, unless the Board of Trade, in any case in which the consent of such Local Authority is refused, are of opinion that, having regard to all the circumstances of the case, such consent ought to be dispensed with; and in such case they shall make a special report, stating the grounds upon which they have dispensed with such consent. The grant of authority to any undertakers to supply electricity within any area, whether granted by licence or by means of a Provisional Order, shall not in any way hinder or restrict the granting of a licence or Provisional Order to the Local Authority or to any other company or person within the same area.

The second section repeals Section 27 of the former Act, and substitutes 42 years for 21 as the time to elapse before compulsory purchase can be enforced. Section 3 gives power to the Board of Trade to vary the terms of compulsory sale in accordance with any agreement between the Local Authority and the undertakers. Section 4 is very important, as it empowers the Board of Trade to make regulations for the protection of the public safety and of telegraphic and telephonic lines in the case of any electric lines used for the supply of electric energy, however laid or erected, and whether under statutory powers or not. Perhaps I had better read the first part of this section—

4. *Restrictions as to Placing of Electric Lines, &c.*—(1). Where in any case any electric line or other work may have been laid down, or erected in, over, along, across, or under any street, for the purpose of supplying electricity, or may have been laid down or erected in any other position for such purpose in such a manner as not to be entirely enclosed within any building or buildings, or where any electric line or work so laid down or erected may be used for such purpose otherwise than under and subject to the provisions of a licence, Order, or special Act, the Board of Trade, if they think fit, may, by notice in writing under the hand of one of the secretaries or assistant secretaries of the Board of Trade, to be served upon the body or person owning or using or entitled to use such electric line or work, require that such electric line or work shall be continued and used only in accordance with such conditions and subject to such regulations for the protection of the public safety and of the electric lines and works of the Postmaster-General, and of other electric lines and works lawfully placed in any position and used for telegraphic communication, as the Board of Trade may by or in pursuance of such notice prescribe; and in case of non-compliance with the said regulations, then the Board of Trade may require such body or person to remove such electric line or work: Provided that nothing in this subsection shall apply to any electric line or work laid down or erected by any body or person for the supply of electricity generated upon any premises occupied by such body or person to any other part of such premises.

Sub-section (2) provides for the Postmaster-General taking action himself in the case of lines not laid under statutory powers, in the event of actual interference with his telegraphic lines, provided that these lines are not already regulated by the Board of Trade. The general purport of the section is to place the responsibility for the proper regulation of electric supply wires generally on the Board of Trade.

We now come to the dealings of the Board of Trade with the subject, and I propose to consider in the first place the various forms of Provisional Orders granted under the general Acts. As licences differ very slightly in form from Orders of the same date, it will not be necessary to discuss them.

There are up to the present time four forms of Orders, differing materially from each other in important respects, and showing, I consider, progressive improvement in the treatment of the subject as experience was gained. These are—1st. The 1883 form, of which Bradford is, I think, the only one now actually being worked, but some other Local Authorities are preparing to start under old Orders; 2nd. The Chelsea Order of 1886, and St. Austell licence of 1885; 3rd. The London Orders of last year, which form, I may point out, is only applicable to metropolitan districts under the London County Council; 4th. The model forms of Orders for this year, which were even now being modified in certain clauses and will not attain finality until some points have been determined by the action of Parliament. There are slight variations in form among individual Orders, generally due to some local considerations, and in every case there are considerable differences between Orders granted to Local Authorities and those granted to companies.

The first matter in all the Orders is the interpretation clause. In this, last year an innovation very important to electricians was introduced, viz., the definitions of "energy" and "power"—

The expression "energy" shall mean electrical energy; and for the purposes of applying the provisions of the principal Act to this Order electrical energy shall be deemed to be an agency within the meaning of electricity as defined in the Electric Lighting Act of 1882.

And—

The expression "power" shall mean electrical power, or the rate per unit of time at which energy is supplied.

They hang upon the definition of electricity in the principal Act as "electricity, electric current, or any like agency." Rather a general definition, you see. Now, the use of the term "energy" has, I consider, materially improved the language of the Orders, both from a scientific and a legal point of view. Under the old forms of Orders the undertakers were authorised to supply "electricity," and continual reference is made to this as the quantity supplied. Now, this word has, or had, many meanings, but in this case it could only mean electrical energy. But when we turn to the "Price" clauses we find that energy is expressly mentioned as differing from electricity, and that there, at all events, the latter meant what we now call "electrical quantity." There really was here some confusion of language, distressing to the electrician, and opening up grand possibilities of endless talk to lawyers. The proposed amendment was referred to your Council and concurred in by them, and I am glad to notice that the use of the term "electrical energy" is gradually working its way. I am not yet satisfied, however, with our word for what used to be the particular meaning of electricity. It is rather absurd to call it "electrical quantity," since so many other things are electrical quantities. I almost think we want a word for this even more urgently than for electrical locomotion, over which so much ingenuity has been lately expended. The worst of it is that, as nobody knows what it is, or to what extent its existence is an objective reality, it is difficult to find an appropriate word. At any rate, it was impossible in the Orders to call it "electricity" any longer, as the Act says that is what is to be supplied; so that we had to define "energy" as what was meant by electricity in the Act, and use "electrical quantity" for the particular meaning for want of a better word. This also necessitated an alteration in the title. There is a slight further alteration in the new model title.

As regards the definition of "power," this was necessary to avoid a difficulty in modifying a few clauses in the old Orders which dealt with the maximum current to any consumer to render them applicable to transformer systems. The definition of "main" has been materially altered. Thus it used to mean the conductor alone, then a continuous electric line, defined in the Act as follows:—

The expression "electric line" means a wire or wires, conductor, or other means used for the purpose of conveying, transmitting, or distributing electricity with any casing, coating, covering, tube, pipe, or insulator enclosing, surrounding, or supporting the same, or any part thereof, or any apparatus connected therewith for the purpose of conveying, transmitting, or distributing electricity or electric currents.

And, lastly, the word "continuous" has been omitted as unnecessary in the case of transformer system. The definition of "service line" has been altered in the same way. "Distributing main" has not been altered. It is a very important definition, which I will read—

The expression "distributing main" shall mean the portion of any main which is used for the purpose of giving origin to service lines for the purpose of general supply.

Difficulties may arise in interpreting this, as, for instance, in cases where the same conductor is at one part a feeder and at another a distributing main; but it is one of those things which must be left to custom and precedent.

The other definitions need not detain us now, except that two important ones have been added in the new forms—

The expression "consumer" shall mean any body or person supplied or entitled to be supplied with energy by the undertakers.

The expression "consumer's terminals" shall mean the ends of the electric lines situate upon any consumer's premises and belonging to him, at which the supply of energy is delivered from the service lines.

The consumer's terminals are the point of demarcation between the possessions of the undertakers and their customers; they need not be binding posts.

In the clauses headed "Area of Supply," an important novelty was introduced last year, and has been retained in the new model for companies, expressly prohibiting the undertakers from supplying outside the area granted to them without further statutory powers. This is a sacrifice of their common-law rights which they are required to make in consideration of the special privileges they acquire. You are perhaps aware that this provision is being carried out by mutual agreements between the London companies.

The old Orders, and the Liverpool and Swansea Orders of last year, provided for the division of the whole area into two districts, scheduled A and B respectively; the A district alone being the

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area for which powers are immediately granted, and in which supply is compulsory; while the B district was intended to be added piece by piece, practically at the option of the undertakers. The general effect of this was to induce undertakers to apply for very large districts, the greater part of which were in the B schedules, over which they thereby acquired a sort of prior right of occupation without incurring any liability. This was altered last year and a single district substituted, to the whole of which the "Compulsory Works'" clauses apply.

Nature and Mode of Supply.

In the old Orders two systems were mentioned, viz., the "parallel system," and the "series system," meaning constant-pressure and constant-current systems respectively. Now, no system is specified, except that it must be one approved by the Board of Trade. A new sub-section was added to this last year at the instance of the telephone companies, by agreement with the promoters, for the protection of the telephone circuits against interference by induction or otherwise, they being naturally rather alarmed at the proposed general use of alternating currents.

In the "Works" clauses, I need only mention that in the new model it is proposed to give powers for the construction of "street" boxes in place of "distributing" boxes. The special power taken is necessary, I believe, because these boxes come up to, and may come above, the surface of the ground. Also, that the prohibition of overhead wires, introduced last year, is inserted in the new model for companies, with the alteration that the time allowed for removal of existing overhead wires is reduced to one year. But they may be erected or continued in use with the consent of the Local Authority. This prohibitory section is based upon, and really does not go beyond, section 14 of the Act of 1882.

The "Compulsory Works" clauses provide generally that the undertakers shall do something substantial towards carrying out their undertaking within a specified time, under penalties of fine or revocation of the Orders. The Board of Trade, however, must, in the case of a company, be moved to exercise its power of revocation by the Local Authority, except in the last model, where this has been altered; while in the case of a Local Authority being the undertakers, the Board of Trade has not hitherto, so far as I am aware, thought fit to exercise its power of revocation for non-performance of works within the required time, probably considering the plea that the practical knowledge and experience of electrical distribution was not sufficient to justify any expenditure of public funds, a valid one. This plea, however, is obviously daily diminishing in force. In nearly all Orders the specified time within which mains have to be laid in certain streets is two years. It is three years in the Birmingham Order of last year, but all streets within the area are included. The Liverpool Order is also an exception.

In the old Orders two years was also the period that had to elapse before any supply could be requisitioned in other streets, and six months more is allowed to comply with the requisition. In last year's London Orders and the new forms, however, supply can be requisitioned after eighteen months, with six months for compliance; so that persons in streets not scheduled can get a supply at the same time as those in scheduled streets. Also, in the recent Orders, as already mentioned, supply can be requisitioned for any part of the area included in the Order; whereas in the old Orders it could only be requisitioned for the A district. There is a slight variation, too, in wording, which may be important, viz.: whereas in the old Orders mains were to be laid *in* every street, now it is *throughout* every street.

The requisition to lay distributing mains in any street has to be signed by a number of persons, which number is a very variable quantity in different Orders. Thus in the old Orders of 1883 it was two or more owners or occupiers in the case of an Order given to a company or person, and the owners or occupiers of not less than one-fourth of the premises in the street in the case of a Local Authority. In the Chelsea Order of 1886 it was six or more owners or occupiers. Last year the Board of Trade reverted to the former practice both in the case of companies and Local Authorities, except in the Birmingham and Liverpool Orders, where no power of requisitioning is given to owners. These two Orders are very exceptional in respect of these clauses. This year, in the model forms, which are not intended to apply to London, it is proposed to follow the precedent of the Chelsea Order, and to require six signatures to a requisition, the number being the same both for Local Authority and company Orders.

After the requisition clause follows a long clause intended to provide that the undertakers shall, if they so require, be guaranteed by the persons making the requisition a return for their outlay in laying the requisite mains of 20 per cent. per annum for three years in the old Orders, two years in the London Orders, and again three years in the new model Orders.

After these "Compulsory Works" clauses come a few clauses headed "Maps;" and then, in the old Orders, "Regulations as to Supply on the Parallel System." These regulations are not inserted in any of the recent Orders, but are issued separately with the Safety Regulations. Then we come to some clauses headed "Testing" in all Orders up to this year; but in the new models an improved arrangement has been followed, and "Supply" comes next to "Works," which certainly seems a more logical sequence; also, the clauses applying to the appointment and duties of electric inspectors are now put under a separate heading.

Taking these clauses first, the appointment of electric inspectors is vested, in the case of all Orders to companies, except the London Orders, in the Local Authority; in the London Orders it is vested in the County Council; and in all existing Local Authority Orders in a court of summary jurisdiction, moved either by a consumer or by the undertakers themselves. In the new model this appointment is vested in the Board of Trade. In case of the Local Authority not appointing an inspector, or imperfectly attending to inspectional duties, there is a provision in all company Orders for appointment, in some cases by a magistrate, in others by the Board of Trade.

In the new model Orders a clause has been added specifically stating that the Board of Trade may appoint an inspector for the purposes of any inquiry on an accident or as to safety. I think it is obvious that the Board of Trade has in any case, whether expressed in the Order or not, the right to make inquiry as regards safety.

All local inspectors are to be paid by the Local Authority, or County Council for London; but fees may be charged by means of which part, at any rate, of the cost of inspection will be recouped. Inspectors may be appointed from time to time for particular services, or the appointment may be continuous. It is rather difficult to see how this matter will work in small towns where there may be no resident electrician unconnected with the undertakers, or, at any rate, none who would care to undertake the job for such remuneration as could be offered without unduly increasing the cost of the supply, since the expenses of inspection must in one way or another be borne by the consumers. Probably one electrician will secure the appointment for several towns not very far apart, and reside in a convenient locality for his district. It will be something like the birth of a new species; and some follower of Darwin will in the next century write an exhaustive monograph on the genesis of the electric inspector, showing how he came to differentiate from ordinary mortals, how he gradually acquired an extra sense warning him against high pressure, &c.

The duties of electric inspectors are clearly defined in the new model Orders, as follows:—

> The duties of an electric inspector under this Order shall be as follows:
> (*a*) The inspection and testing, periodically and in special cases, of the undertakers' electric lines and works and the supply of energy given by them;
> (*b*) The certifying and examination of meters; and
> (*c*) Such other duties in relation to the undertaking as may be required of him under the provisions of this Order or of any regulations under this Order.

The next clauses in the new models are headed "Testing and Inspection;" and this is an improvement on the old heading of "Testing" alone, since it is obvious that in the case of a network of mains a good deal may be found out by inspection that could hardly be arrived at by testing. These clauses have been greatly altered, and I would especially draw attention to a new clause—

> 40. *Testing of Works and Supply on Consumer's Premises.*—An electric inspector, if and when required to do so by any consumer, shall from time to time, on payment by the consumer of the prescribed fee, test the variation of electric pressure at the consumer's terminals, or make such other inspection and testing of the service lines, apparatus, and works of the undertakers upon the consumer's premises as may be necessary for the purpose of determining whether the undertakers have complied with the provisions of this Order, and the regulations and conditions subject to which they are for the time being authorised to supply energy.

Which is, I think, very practical, and may have important results. This clause takes the place of the following in the existing Orders:—

> 35. *Testing of Service Lines.*—Every electric inspector, if and when required to do so by any person supplied with energy by the undertakers, shall from time to time test for insulation and conductivity any service lines by which such energy is supplied and the efficiency of any joints in such service lines, and make such other tests in relation to such service lines as may from time to time be approved of by the Board of Trade.

In all Orders there is a clause providing for the establishment of testing stations at various points in the area, either by the undertakers or by the Local Authority. I am not aware that any such testing stations have yet been established; but I believe that in several districts in London they are to be established for one position, at any rate—at the office of the Local Authority. The practical use of these testing stations is obviously to obtain a record of the variations of pressure at different points in the system, and of the duration of any abnormal pressure or stoppage of supply. The best solution appears to be to have a recording voltmeter at

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each station, which might be made in the shape of a pillar box; and possibly an indicating voltmeter exhibiting the pressure at any time would be a welcome addition. I consider that the production of a thoroughly trustworthy recording voltmeter is distinctly a desideratum for the improvement of electric supply. There appear to be very few such instruments in use at the present time.

In all Orders I think there is reserved an appeal to the Board of Trade against any report of any electric inspector. It is to be hoped that this power will be used with discretion, as the electrical staff of the Board of Trade is strictly limited at present.

Now, taking the "Supply" clauses, we have, first, that any owner or occupier of premises situated within a certain distance of any district main can demand a supply. This distance is in the 1883 Orders 25 yards; in the London Orders and the new forms, 50 yards. He may be required, however, to pay the cost of service lines beyond a distance of 30ft. in the old, 60ft. in the London and new model Orders. He must name a maximum current in the old Orders, or a maximum power in the new, so that the proper size of service lines may be laid, and this maximum must not be larger than what may reasonably be expected to be the consumption on the premises; and if afterwards he wishes to go beyond the declared maximum, he must be prepared to pay for any alteration of service lines or apparatus thereby rendered necessary. The person requiring a supply must also be prepared to make a contract to take and pay for a supply for at least two years of sufficient amount to pay 20 per cent. on the outlay incurred by the undertakers. Then follow provisos as regards security for payment, prohibition of improper use of the supply, and a very important one added last year, which I will read. The "Price" clauses have been considerably affected by the supply being now considered a supply of energy, and not, as formerly, of electricity. I will read the first clause as it stood in the old Orders and in the London Orders:—

31. *Price.*—The undertakers may charge for electricity supplied by them to any consumer (otherwise than by agreement)—(1) By the quantity of energy contained in such supply; or (2) By the actual quantity of electricity so supplied; or, unless the Board of Trade from time to time otherwise direct; (3) By the number of hours during which the supply of electricity is actually used by such consumer, and the maximum current with which he is for the time being entitled to be supplied.

50. *Methods of Charging.*—The undertakers may charge for energy supplied by them to any ordinary consumer (otherwise than by agreement) —(1) By the actual quantity of energy so supplied; or (2) By the electrical quantity contained in such supply; or, unless the Board of Trade from time to time otherwise direct; (3) By the number of hours during which the supply of energy is actually used by such consumer, and the maximum power with which he is for the time being entitled to be supplied.

In the new models method (3) has been altered as follows:—

32. *Methods of Charging,*—The undertakers may charge for energy supplied by them to any ordinary consumer (otherwise than by agreement)—

(1.) By the actual amount of energy so supplied; or,
(2.) By the electrical quantity contained in such supply; or,
(3.) By such other methods as may for the time being be approved by the Board of Trade.

The reason for this is that the old method (3) is decidedly wasteful, and, if generally adopted, would lead to far more energy than was necessary being supplied from central stations. Except in special cases, such as lighting of shops and business premises, it should be noted that the consumers are free to make any agreement they prefer as to the price to be charged and the method, but they have a right to be charged in accordance with methods (1) or (2), and the undertakers are always bound by the undue preference clause.

The meter clauses have hardly been altered at all, and it is, in my opinion, proof of the very great care and acumen with which these clauses were originally drawn, so far back as the year 1883, that no really satisfactory improvement has yet been proposed. These clauses will repay very attentive study. They are sometimes looked upon as stumbling-blocks, and it is said that they are unintelligible, and that they won't work; but I am afraid that these difficulties are rather due to want of study and defects of meters than to the clauses themselves. They are too long to take in detail, but, roughly, the gist is as follows:—

Any number and description of meters may be used both by consumer and undertakers, but only one meter is to be used for ascertaining the value of the supply. This is to be a meter certified by an electric inspector appointed under the Order. Note that it cannot be certified by anyone else. The inspector must certify three things—(1st) That the meter is of some construction and pattern approved by the Board of Trade; (2nd) That it has been fixed and connected to the service lines in some manner approved by the Board of Trade, which must, therefore, in approving any pattern of meter, prescribe in what way it is to be fixed and connected to the service lines; (3rd) That it is a correct meter; and in making this last declaration the inspector, in my opinion, may reasonably take account of and be guided by any mark or certificate attached to the meter showing that it has been thoroughly tested and found sufficiently accurate to be pronounced a correct meter in some standardising laboratory, or he may himself carry out the necessary tests in a laboratory. It is obvious that he cannot thoroughly test it in the consumer's cellar, and also that the words "a correct meter" cannot be held to be only applicable to a meter that was absolutely perfect throughout its range. The undertakers are to supply the consumer, either by purchase or hire, with a meter on demand, and procure its certification. No consumer is allowed to connect or disconnect the meter used for ascertaining the value of the supply without giving 48 hours' notice to the undertakers, under penalty. If this meter belongs to the consumer, he is to keep it in proper order, but if it is hired from the undertakers they must maintain it; and in either case they may remove it for testing, all expenses connected with the removal being paid by the consumer if the meter turns out to be faulty, and by the undertakers if it is in proper order; and any other meter or apparatus placed by the undertakers upon the sumer's premises for the purpose of ascertaining or regulating the supply of energy must be of some construction and pattern and connected in a manner approved by the Board of Trade.

The only other point in the Orders of much electrical interest is the Price Schedule. In this the definition of the Board of Trade unit has remained unaltered, except the simplification of the wording. Last year there was, as you may remember, some agitation to have the amount of the unit increased tenfold. The point was referred to your Council, who did not recommend the alteration, and the Board of Trade very willingly left it as it was. Of course, undertakers are at liberty to make agreements for a price per 10 units, provided that the charges do not exceed the rates laid down in this schedule.

In the London Orders of last year there was added to the second section a proviso to enable the standard pressure on the mains to be taken into account in assessing the value of the supply where this pressure is a high pressure, and the energy is transformed; but in the new model this section has been much simplified by the introduction of a new term, viz., the declared pressure at the consumer's terminals, which it is proposed to deal with in the new regulations.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, June 6th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: (1). "The Effect of Change of Temperature on the Villari Critical Point of Iron." By HERBERT TOMLINSON, F.R.S. (2). "The Diurnal Variation of the Magnet at Kew." By W. G. ROBSON and S. W. J. SMITH.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Search for Coal in the South of England." By Prof. W. BOYD DAWKINS, F.R.S.

SATURDAY, June 7th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Ballad Music of the West of England." By the Rev. S. BARING-GOULD, M.A.

TUESDAY, June 10th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Natural History of Society." By ANDREW LANG.

THURSDAY, June 12th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "Flame and Explosives." By Prof. DEWAR, F.R.S.

SOCIETY OF ARTS.

5 p.m. Indian Section: "The Rationale of Indian Railways." By Sir THEODORE C. HOPE, K.C.S.I.

FRIDAY, June 13th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Physical Foundation of Music." By Prof. SILVANUS P. THOMPSON, D.Sc.

SATURDAY, June 14th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture: "The Ballad Music of the West of England." By the Rev. S. BARING-GOULD, M.A.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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THE PHYSIOLOGICAL EFFECT OF ELECTRIC CURRENTS.

A subject of great importance in connection with the rival merits of alternating and continuous currents is their physiological effect upon the human body. The great difficulty of finding a method of test which shall be beyond criticism is, no doubt, mainly responsible for the fact that comparatively little time has yet been spent on such investigations. It is, however, a matter of universal interest to ascertain how far it is necessary to adopt greater precautions to avoid danger when alternating potentials are used, than when direct ones are employed; and experiments with this object in view are accordingly much to be desired, even if the results obtained require subsequent modification. Contributions from the medical side are of special value, and for this reason the recent Paper of Messrs. LAWRENCE and HARRIES has done good service in emphasising the physiological aspect of the question. Electricians are, perhaps, somewhat inclined to treat the human body as an inanimate conductor; and it is, therefore, opportune to point out the great distinction which must be drawn between the resistance presented by the body to the flow of an electric current, and the sensation of discomfort produced by its passage.

If the title of their Paper had been less comprehensive there would be nothing but praise to bestow on its authors, recording as it does the results of many interesting experiments; but the words "alternating v. continuous currents" cannot but call to mind a controversy with which the tests in question have little to do; and the only legitimate conclusion which can be drawn from the sensational danger ratios given by the authors is, that their experiments can have little

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bearing on the practical points at issue, since the results asserted are quite at variance with actual experience. It is, indeed, unfortunate that the results of the experiments were embodied in a form so ambitious as is indicated by the word *danger-ratio*, for only a most comprehensive research could justify such a course. It is not surprising, considering the importance of the question, and the anomalous nature of the results, that the Paper should have provoked considerable criticism; and our correspondence columns have indeed recently contained several reasons for modifying the conclusions drawn.

As we have already hinted, it is practically impossible to make tests of this kind in a manner which is not open to objection, however great may be the care bestowed on the actual experiments. The measurements of resistance must be accepted with considerable caution. When intermittent or alternating currents are employed the self-induction of the resistance coils in the bridge and the capacity of the human body would each tend to make the resistance appear less than for direct currents, especially with so high a frequency as 300 per second. An excellent instance of the misleading results it is possible to obtain under somewhat different circumstances, unless great precautions are adopted, is given in the letter of Mr. Otto T. Bláthy. It is here stated that the resistance of his assistant when grasping two stout copper electrodes was found to be between 4,000 and 5,000 ohms for both direct and alternating currents, the testing potential used being 30 volts in the former, and 15 volts, alternating at 50 periods per second, in the latter case. This was when a Wheatstone bridge specially arranged so as to be devoid of self-induction was employed. When, however, a large Elliott bridge was used, with a potential of only 8 volts, the same assistant presented a resistance of 15,000 ohms. This experiment sufficiently indicates the importance of self-induction, but it shows in addition the influence of the testing potential on the results obtained. The fact that the potentials employed by Messrs. Lawrence and Harries were not the same when direct and intermittent currents were used is alone sufficient to render the comparison unfair; and if the true resistance of the human body to direct and alternating currents really differs in consequence of properties peculiar to living organisms, it is none the less necessary to perform the different tests under comparable conditions. The smallness of the potentials used in the tests, compared with those common in practice, gives weight to an objection of Mr. Kennelly, who has cast doubt on the measurements because the effects of polarisation are included in the values given for the resistance. No doubt, as Mr. Lawrence points out, it is the apparent resistance which determines the danger ratio, since the true resistance and the spurious resistance due to polarisation act together in preventing the passage of electricity through the body. As, however, the relative importance of these factors will vary considerably with the potentials employed, it is obvious that no certain conclusions with reference to practice can be drawn from experiments made with potentials differing widely from those actually in use.

It is, however, in connection with the sensation tests that there is most need to take exception to the results. Mr. Sayers has drawn attention to an important inference which the experiments suggest. It would appear that, under conditions of contact which are intended to reproduce those occurring in practice, it only needs a little over six volts to produce muscular fixation when intermittent currents are employed. Whether or not it is reasonable to suppose that 10 times this potential should produce death, the ratio of the potential actually required to kill to that needed to bring about muscular fixation, certainly seems, according to these experiments, incredibly high. The main reason for the unexpected character of the results is, in all probability, that pointed out by Prof. Forbes. The intermittent currents given by the induction coil differ very widely from the alternating currents known to electrical engineers. While, with the latter, the maximum current is only about half as large again as the mean, with the former the maximum current rises to many times the effective current. The measuring instruments employed indicated the average current; and we have only to assume that the sensation of discomfort is due to the maximum value of the current to sufficiently account for the great divergence of the danger ratio given from that which practical experience indicates. The truth of this explanation can readily be tested by repeating the resistance and sensation measurements when the alternating currents employed are of the usual harmonic type. It may even be possible to obtain differences in the measurements by simply altering the adjustment of the vibrating contact maker of the induction coil.

A valuable contribution to our knowledge of the physiological effects of electric currents has recently been published by Dr. Edward Tatum, and a brief description in our American Notes of his experiments will be found in *The Electrician* of the 23rd May. Dogs, not human beings, were the individuals tested; but, on the other hand, the currents used were such as to produce death; so that the experiments are perhaps more applicable to the important question at issue than others in which only feeble currents are employed. A most important conclusion arrived at is, that the action of the current is something more than an action on the nerves. With dogs, at all events, the chief mischief is due to an action on the heart, although both brain and heart are affected. It was found that the mean value of an alternating current need only be of about half the value of a direct current to produce the same deadly effect. When, however, the dogs were etherised, and rendered insensible to nerve action, no difference whatever was detected between the fatal powers of continuous and rapidly alternating currents. Dr. Tatum very forcibly concludes that, as currents may be fatal when all sensibility to pain has been abolished, and when there is no discoverable action on the nerves or muscles, we have no right to gauge the fatal powers of different kinds of currents by their relative capacities for exciting muscular contraction, or sensations of pain. The currents that have greater killing powers can only be found out by direct experiments with currents that kill.

THE DUNCAN MULTIPOLAR MOTOR.

We are indebted to the *Electrical Engineer* of New York for the following particulars with regard to the multipolar slow-speed motor recently designed by Dr. Louis Duncan, of Johns Hopkins University. This machine was briefly referred to by our New York correspondent in our issue of May 30th.

In Fig. 1 we have the motor in perspective and partly in section, and it will be seen to consist of an armature C, which is centred on the shaft A, and which is under the inductive action of the magnets N S, the form of which is more clearly shown in Fig. 2. These consist of a cylindrical portion which is shrunk on the shaft and have polar projections bent so that their inner surfaces form right angles enclosing the armature, and so arranged that the ends of the projections on the one side are midway between the projections on the other side. The illustration shows the armature having 28 polar projections, 14 on each side. The essential feature is that the polar projections of one polarity on one side are opposite the spaces between those of opposite polarity on the other side and fewer by some even number than the

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coils on the armature, the object of which will be described presently.

In the machine illustrated the field magnets revolve and are attached to the shaft, A, which it drives. The armature C is stationary, being held fast by the lugs shown. The armature is a ring similar in form to the well-known Pacinotti or Gramme ring, but differing essentially as to the method of winding. In a motor having 28 polar projections, as the one illustrated, it has 30 coils surrounding it, the adjacent coils being wound in opposite directions instead of all being in the same direction, as in a Gramme ring. This is shown in Fig. 2, there being a wire taken from the junction of the adjacent coils *d d'* to one bar of a 30-part commutator, as in the ordinary Gramme armature.

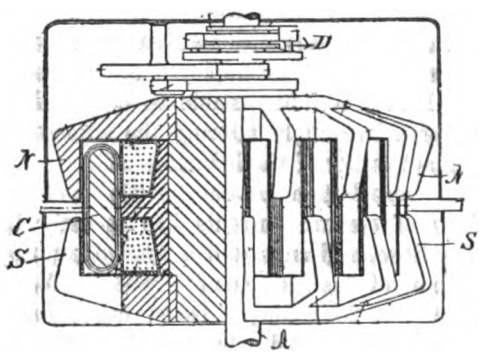

FIG. 1.

The commutator may be stationary, as shown in Fig. 1, or revolve. In the former case the brush holder is revolved by a series of gear-wheels, so that the brushes make fourteen revolutions for every revolution of the magnets. In another form of commutator there are 420 segments, forming the commutator-bars, divided into 28 groups of 15 segments each. It will be observed that there are one-half as many segments on the commutator as results from the multiplication of the number of polar projections by the number of coils on the armature. In this case the commutator turns with the motor shaft.

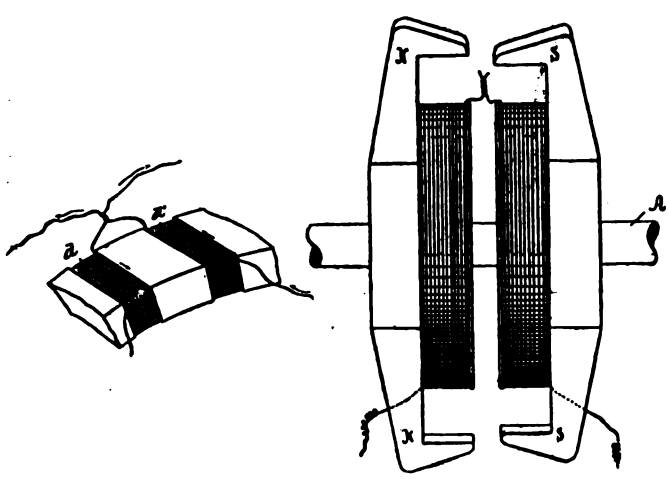

FIG. 2.

When the current passes through the armature all the teeth of the armature are energized excepting those between the pairs of coils on opposite sides of the armature in connection with the brushes. These portions, by reason of the direction of the current and the windings of the coils, are not energized. The connections of the brushes are so arranged that when the current enters these coils the teeth between them are exactly opposite the polar projections of the field-magnet. When the commutator has moved through $\frac{1}{420}$th of a revolution, the teeth between the succeeding coils will be exactly opposite the succeeding polar projections. The same instant the brushes pass upon the succeeding segments of the commutator. These segments are divided into groups of 15 each, and it is so provided that all the segments of each group send the current in the same direction, and also that each succeeding group of segments shall change the direction of the current. It is evident that there will be 28 changes of the current at each revolution of the commutator—a number corresponding to the number of polar projections in the field-magnet.

The result of this arrangement is a steady continuous pull at the periphery of the armature, which permits of obtaining a high efficiency at a comparatively slow speed.

LEGAL INTELLIGENCE.

King, Brown and Co., v. The Anglo-American Brush Electric Light Corporation.

The discussion in the reclaiming note against Lord Trayner's judgment in the action King, Brown and Co., Edinburgh, v. The Anglo-American Brush Electric Light Corporation, was resumed in the First Division of the Court of Session, Edinburgh, on Thursday last week.

Mr. JAMESON, for the Brush Company, continued his speech. He proceeded to contend that the segment T was meant to be a conductor as well as an insulator, and was more mechanical than anything else. Lord Trayner, in his judgment, admitted that as a mechanical arrangement it was new and useful, and not open to challenge. "But," his lordship proceeded, "the pursuers maintain that the letters patent under reduction are rendered invalid by reason of the patentee claiming in his final specification (as amended and described) something with reference to the commutator as an invention which is not foreshadowed in the provisional specification. The claim here referred to is the fourth, which is in these terms:—'The commutator having metallic insulating segments substantially as shown in division three.' It appears to be necessary, or at least desirable and advantageous, to cut the armature bobbins out of circuit T, when they are crossing the neutral or current-reversing points of the magnetic field. To do this the continuity of the current-conducting segments of the commutator has to be broken either by a mere space or by the insertion of some non-conducting material at the given point. The cutting of the bobbins out of circuit was known and practised before the defenders' patent, but it was not before then done by means of an insulating metal segment. The advantage which attaches to the defenders' method is this, that the insulating segment being metal, like the conducting segments, there is insured a certain uniformity of wear over the entire surface of the commutator, which could not be preserved where a softer material was used, or where merely a space was left. I am not aware that prior to the defenders' patent any insulating body, metal or otherwise, was ever used in the construction of the commutator, for the purpose of cutting the bobbins out of circuit. The insulating segment T of the defenders' patent was therefore a novelty, and its utility I do not understand to be disputed. But was it foreshadowed by the provisional specification? I think not. In the first place the defenders' second claim seems to me to be co-extensive with the provisional specification (in so far as it relates to the commutator) so that there was nothing left to claim under another head. If all that was foreshadowed in the provisional specification is included in the second claim, then the fourth claim, unless regarded as mere repetition, which nobody suggests, is for something not there foreshadowed. Secondly, the provisional specification relates only to the construction of a cylindrical commutator, whereas one of the chief purposes of and one of the main advantages to be derived from the insulating segment T, is the preservation or maintenance of the cylindricity of the commutator, an object probably as important and as patentable as—but quite distinct from—the shape or mode of construction. Thirdly, the insulating segment T is not merely or necessarily a part of the cylindrical commutator having sub-segments with wearing segments detachably attached. It has, and is intended to have, a peculiar function, which is not referred to in the provisional specification at all. Fourthly, it is said that the segment T is a part of the wearing segment, and therefore falls within the description of the provisional specification; but I think this is not so. The wearing segment is an essential part of the defenders' commutator, the segment T is not. It may be dispensed with altogether. I come, therefore, on this part of the case, to the conclusion that the patent sought to be reduced is invalid, in respect that the invention claimed in the final specification is larger and different from that claimed in the provisional specification." Now, Mr. Jameson proceeded, in the specification Mr. Brush desired it to be understood that the insulator T need not of necessity be material. It was really a wrong construction of the patent altogether to take up this opinion in order to avoid their claim as to this insulator T, because Mr. Brush did not claim the hub in which the T did not occur. But for the sake of publication he said "that if anybody liked to construct a commutator like mine having the other elements or integers of my invention, but chooses to leave out the segment T; or to substitute for it a wooden segment, or something of the sort, he might do so if he chose." Mr. Brush secured by that that his invention should not be pirated. He did not claim the insulator T; and it was an extraordinary construction of the patent to say that after having given notice of this to the world generally he was to be held as invalidating his own claim for T altogether. He quoted the evidence of Prof. Perry, Sir William Thomson, Mr. Brush, and Mr. Imray, and said that of course there were two views taken by witnesses upon the point; but he submitted that the sound view, taking

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that explanation as to the effect of the arrangement, was that Brush showed he intended to construct cylindrical commutators. Certainly he meant commutators which were cylindrical, and which would preserve their cylindrical form by the various devices which he set forth. He thought that matter was really disposed of when one considered the objects of a provisional specification. Chief Justice Boyle said that "the object of a provisional specification was only to describe generally and fairly the nature of the invention, and not to enter into all the minute details as to the manner in which it was carried out. Otherwise a provisional specification would require to be a full and complete specification. The statute itself clearly indicated the distinction, because it called the latter a complete specification, implying that the former was in some respects incomplete. Moreover, it indicated that a provisional specification was to describe the nature of the invention and no more." Now, this was a description of a cylindrical commutator with an insulating hub and metallic sub-segments placed in connection with the general mechanism, and metallic wearing segments detachably attached to said sub-segments. Now, these were metallic segments in all cases in which the claim was made. No doubt the inventor said he might dispense with part of his wearing segments, but that was plainly an invention.

Mr. GRAHAM MURRAY: I may say that I do not think there is anything between us in the law. All that a provisional specification may do is to disclose the nature of the inventions. But then if I can show that the final specification has got a different invention in it from the one in the completed specification, then the patent is invalid.

Mr. JAMESON said they submitted that every item of all these claims carrying out the construction of a cylindrical commutator, with an insulating hub and metallic subsegments and wearing-segments, was clearly enough foreshadowed in the provisional specification. It did not matter if in perfecting that invention they said that some wearing segments might be attached to others in the adjoining part of the cylinder, or that part of the wearing segments might be so arranged as to cut out the bobbins. They did not claim as an invention the cutting out of bobbins, but they were claiming the invention of a commutator which was to be used in connection with a machine otherwise described, in which the cutting out of the bobbins was an object to be attained. Therefore, they adapted that mechanical appliance to the machine in which they are to use it, but they did not claim the cutting out of the bobbins, but simply claimed a cylindrical commutator, and they introduced a certain form into it—these wearing segments—so as to meet the cylindrical requirements of the machine. That being so, he submitted they were fairly within the provisional specification, and that it would be altogether too stringent a construction of the provisional specification to say that it did not fairly cover everything that was claimed in the completed specification. That concluded what he had to say upon the point of the commutators. He now came to the much larger and more important question, he thought, in every sense of the word—the question of the series-shunt winding. There were a number of anticipations alleged upon record, but they were all narrowed down to the anticipation by that publication contained in Varley's specification, and the alleged public user by Varley's machine. Therefore, he might confine their attention to an investigation into Varley's specification, 4,905 of 1876.

LORD McLAREN: I suppose if Varley's specification be actually an anticipation, it is not necessary to prove that the design there described was for use.

Mr. JAMESON: No; publication is sufficient; but then, he added, the law which had already been laid before the Bench came in that for a completed specification there must be such a description as will enable a workman of ordinary skill to make a machine of the kind described; and they must remember in that particular investigation that they must not take a skilled workman of the present day, but a workman of ordinary skill of 1876, when Varley's specification was published. They must also bear in mind that if there were publication here, and that most important invention lay open to everybody, nothing was done from that day to this except to make that particular machine, which was made upon Varley's own orders in the works of Siebe and Gorman, who were Varley's partners.

The LORD PRESIDENT: Suppose Varley's invention was only disclosed in the provisional specification; if that was earlier in date than yours, then you are not the person who first invented it.

Mr. JAMESON: That would be so.

The LORD PRESIDENT: It does not require a complete specification.

Mr. JAMESON: It is a complete specification, but I say it was not sufficient to enable a workman to make it.

The LORD PRESIDENT: Suppose it is complete. If that specification discloses fully the nature of the invention, but does not sufficiently describe the method in which it is to be made to enable a workman of ordinary skill to make it, still you would not be the true inventor.

Mr. JAMESON: I think in law we would be entitled to the patent.

The LORD PRESIDENT: I do not think that.

Mr. JAMESON: Unless he published and used it,

The LORD PRESIDENT: He published it in the specification.

Mr. JAMESON: But it must be publication such as would enable a workman of ordinary skill to make it.

The LORD PRESIDENT: No. It is publication of the invention that would be an anticipation of yours, although there is no description of how it is to be carried out.

Mr. JAMESON: I shall consider that point. I am not prepared at present to meet it.

The LORD PRESIDENT: I am afraid that is the law.

Mr. JAMESON: A patent was really founded upon this principle, that every person who made an invention and got a patent for it should so describe it as that the invention shall be useful to the public.

The LORD PRESIDENT: That is essential to the validity of his patent, but he may be the first inventor although he has not got a good patent.

LORD McLAREN: Suppose a man had described a patent in his specification without giving details, would not that be a good patent?

Mr. JAMESON: Not unless it shows enough to enable a workman of ordinary skill to make it.

The LORD PRESIDENT: I do not think that. Suppose a man had described an invention in a magazine which was read by the public?

Mr. JAMESON: That would be a different question. We are here upon a specification, and upon nothing else. If persons are to get advantage of the publication in the specification that must be complete.

The LORD PRESIDENT: What is your authority for that?

Mr. JAMESON: I shall endeavour to get that authority at a later stage.

The LORD PRESIDENT: There are many cases in which a man has lost his patent through defects in the specification, but he did not cease to be the inventor of the machine; and the question here is, whether you or Varley was the first or true inventor?

Mr. JAMESON: Certainly. And we say that not only is there that wanting in the specification, but really that Varley himself did not understand or invent this.

The LORD PRESIDENT: That you are quite entitled to try to make out.

Mr. JAMESON said that at the time of Varley's specification in 1876 there had only been series and shunt-winding, the machines then having separate modes of excitation, either inside or outside, drawn from a separate source. Shunt-winding was hardly known. It had only been spoken of in the communication by Sir Charles Wheatstone, and that was in 1867, but that was hardly shunt-winding. It was shunt in a fashion, but it might quite as well have been described as a short-circuit series machine. But in 1879 Sir Wm. Siemens took out a patent for shunt. That was the first time a patent was taken out for a shunt except by Brush, who afterwards disclaimed it in consequence of this communication by Wheatstone to the Royal Society. Therefore in 1879 they had it in evidence that the shunt arrangement was not likely to be known to the world. The first time shunt machines were exhibited and were commercially successful was in 1881. They were shown at the Exhibition in that year, and came into general use. Now, he asked their lordships to turn to Varley's specification. They might take it as admitted that Brush's specification clearly and distinctly set forth this compound winding. Their claim was, "In a dynamo-electric machine the wire or helix E having a comparatively high resistance and kept in close circuit while the machine is running in combination with the magnetic wire or helix F as commonly employed, substantially as shown in division four." In his specification Haddan said, "My invention has for its object the maintenance in dynamo-electric machines of a 'magnetic field' while the machine is running, whether the external circuit is closed or open. In dynamo-electric machines as ordinarily constructed no magnetic field is maintained when the external circuit is opened except that due to residual magnetism; hence the electromotive force developed by the machine in this condition is very feeble. It is only when the external circuit is closed through a resistance not too large that powerful currents are developed, owing to the strong magnetic field produced by the circulation of the currents themselves around the field-magnets. Such machines are not well adapted to certain kinds of work, notably, that of electro-plating. I attain my object by diverting from external work a portion of the current of the machine, and using it either alone or in connection with the rest of the current for working the field-magnets." Now, turning to Varley's specification, Varley states, "This invention is an improvement on a previous invention, for which provisional protection was granted to myself in conjunction with Cromwell Varley, bearing date December 24, 1866, but which was not proceeded with, and which invention was made the subject of a second application, and for which letters patent were granted to us, bearing date June 15, 1867." Varley then went on to state that in the previous provisional specification a method was described which might be said to have marked a new era in the construction of dynamo-electric machines used for producing the electric light. Nearly all the subsequent machines, Varley proceeded, which had been designed for this purpose depended for their action on the principle first described in the provisional specification. This principle consisted in causing electricity and magnetism developed by the expenditure of mechanical force to act and react on one another in the machine itself, in such a way as to develope a greatly increased amount of both these forces. Such increased amount of magnetism and electricity, as was well understood, involved an increase in the consumption of mechanical force for giving motion to the machine. The development of electricity and magnetism, such as Varley described, Mr. Jameson contended, was not at all the development which took place by winding coils to the magnets with wires, through which the electric current was running, thereby increasing the magnetism. Mr. Varley said that his improvement consisted in separating the development of the electrical and magnetic forces to a considerable extent, obtaining thereby greatly increased magnetic potential in the bobbins, which, at a later stage, became converted into electricity of a correspondingly high potential. He effected this by what might be described as splitting up the bobbins. Mr. Varley did not confine himself to Faraday's discovery as to the electric current in the bobbins, but he talked about magnetism in the bobbins, instead of in the magnets. It was most important for the Court to consider that this invention of Varley's described a particular machine for carrying out a principle which had nothing whatever to do with compound winding, and referred back to a machine in which the development of magnetism in the magnets was caused in a totally different way from that which Brush had patented. Mr. Jameson proceeded to criticise in detail the different clauses of Mr. Varley's specification, directing particular attention to the clause "part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light. There are several well-known ways of doing this, but the method I prefer is to wrap the soft iron magnets with two

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insulated wires, one having a larger resistance than the other—the circuit of larger resistance is always closed and the circuit of less resistance is used for the electric light." Mr. Jameson said it might be that with their present state of knowledge Varley had described a series shunt; but the question was whether Varley understood what he was talking about. and was it described in such a way that any person could understand it. Varley went on to describe a machine, and when they came to the end of his claims they found that there was no claim whatever made for this so-called invention.

LORD McLAREN: He did not claim compound winding; but perhaps he did not claim it not because he did not understand it, but because he did not think it was new.

Mr. JAMESON replied that Varley made the excuse that he thought it had been anticipated by the invention described by his brother, between whom and himself feelings were very hostile. This brother, Cromwell Varley, read a Paper to the Royal Society, in which he described wire or sheet copper put round the magnets so as to preserve a certain amount of residual magnetism; but to close the reference to Varley's specification Mr. Jameson drew their lordships' attention to the diagrams, and stated that they would look in vain for any indications of a series-shunt winding machine. Mr. Jameson then went on to quote at considerable length from the evidence of Prof. Silvanus P. Thompson as to the electrical absurdity of Mr. Varley's suggestions. He next quoted at great length from Sir William Thomson's evidence, to the effect that if anybody followed the directions in Varley's specification he would produce an unworkable machine. When they came in the middle of this specification to the lines regarding the winding, that might now be held to describe compound winding. They were not inconsistent with it, except as to the first two lines. Reading that now, it would be easy for any person to get rid of these two lines, and say they were a mistake. But going back to the state of knowledge at the time the machine was made, in Sir William Thomson's opinion it would put any person off the scent. And although a person might be led to it as in one passage, it was not such a description as to amount to an anticipation of Brush's patent. It was very important with regard to the state of Varley's own mind to consider this matter, because he had no conception of what he was doing himself. That was shown by Varley's own evidence, because he did not claim this great improvement, as he considered he was anticipating. But Sir William Thomson and the other skilled witnesses said Varley's specification had nothing whatever to do with series-shunt winding. Mr. Preece and Prof. Perry and Mr. Brush had all given evidence of a very decided nature. Mr. Brush's machine had remained in use until the present day, with hardly any modification of its original construction. Now, the next thing he asked attention to was the history of Varley's machine, and the mention of prior use. He contended that it was not proved that this machine was a compound-wound machine. There were two wires certainly upon the magnets, but they were arranged in such a way that they might be coupled up in a great variety of manners owing to the number of terminals they had in the machine. Accordingly, as they were coupled up in one way or another, they might either have series-shunt machines or a shunt machine, or perhaps a machine excited separately. Whether that were so or not he (Mr. Jameson) submitted there was no public user in the proper sense of the word, as this was properly an experimental machine; and that although numbers of the public witnessed the experiments, they came to nothing more. He therefore appealed to the law that merely experimental machines, never brought into regular use and thrown aside altogether, would not be permitted to invalidate a subsequent patent of a useful invention.

The LORD PRESIDENT: If the other side is right in holding that Varley's disclosure was an anticipation of your invention, it does not matter whether it was used afterwards or not.

Mr. JAMESON: That is so.

The LORD PRESIDENT: But, on the other hand, if it is not a disclosure of something equivalent to your invention, although it is used, that will not interfere with your invention. What bearing has this upon the present case?

Speaking with regard to Cromwell Varley's communication, Mr. JAMESON said that Varley was put into the witness-box and cross-examined as to why he did not claim this as an invention. His reply was that he did not claim it because of the communication of his brother Cromwell, with whom he was on very bad terms. That was very important, because it showed that he did not know that it was compound winding; or it showed that at best he had an exceedingly hazy notion of what he was thinking of. Now, if he had no clear conception of what he was recommending, and no clear conception of the effect of it, he would be very unlikely indeed to describe it in clear enough language to allow other people to understand it. Putting the case in the strongest view for the other side, what he said was, that all Varley had was a very hazy and indistinct notion of winding the magnet with two wires, and that he had no clear conception of how these would act, and how the machine was to be coupled up. Even assuming this specification is intended to disclose series-shunt winding, and that this machine is made in conformity with that specification, it is quite possible that my friend would not be able to succeed upon the point of the user of his machine. For instance, if you turn to the evidence of Gorman and others, who were connected with the firm of Siebe, Gorman and Co., at whose works Varley's machine lay for some time, their evidence showed that on all occasions upon which the machine was brought out it was for the purpose of seeing what mechanical requirements were necessary to make that machine go well. After trying it again and again it was put aside, and the result was that Mr. Varley became convinced it was an unworkable machine. Instead of making it public or doing anything more about it he sent it away to this gun metal store of Siebe and Gorman's, and allowed the machine to remain there from 1877 until 1887, when it was brought out for the purposes of the case against Mr. Brush. That was the history of the machine. As to the machine itself, Sir William Thomson and Professor Perry both said it was plainly an experimental machine, on account of the quantity of terminals. Then Mr. Preece said that Mr. Varley made a series machine in 1866 and exhibited it at the Inventions Exhibition of 1885. Mr. Varley was awarded a gold medal for it, but nothing was said about the wonderful discovery of series shunt he alleged he had made in 1876, nor of the machine which was constructed on that principle. Mr. Jameson contended that he had shown very clearly not only what sort of machine this was, but also what even the inventor thought of it. Mr. Varley did not bring it forward at all at this Exhibition of Inventions, and nothing was heard about it until it was brought out in the Crompton case. Varley himself was asked about this, and he gave some excuse about pecuniary affairs. He said he was carrying on experiments with the machine, and also making fresh machines to carry out their experiments. Even by his own confession, Varley had begun then with experiments. He would shortly point out to their lordships the history of the Brush machine. In point of fact, it had been largely used at home and abroad. Mr. Imray himself, a witness for the pursuers, admitted very candidly that the series-shunt contained the constant potential, and, at all events, the self-regulation. Mr. Brush brought in this self-regulation to an extent never before approached. It had come to be worth a great deal since the introduction of the incandescent light. The result had been that this machine of Mr. Brush's had been published, and it was taken up by a company, and the machines had been sold both in this country and America since 1878, when this patent was taken out. That was all he need say upon the evidence in the case, and the next matter was the question of law applicable to the evidence. As to the law, he had to say generally that whatever was essential to the invention must be read out of the prior publication. The question was whether this patent of Varley's disclosed such specific details of compound winding as to amount to prior publication of this discovery patented by Brush. Brush set forth his object, but there was no object set forth by Varley. Varley's object was apparently the extraordinary one of storing up electricity in the bobbins; and the details led to confusion. Varley went on to suggest certain ways of winding the magnets, but he gave no specific directions that would enable a person to carry that knowledge into useful effect. Then they had the most learned electricians in the world telling them that the specification was full of misleading information. The result was that no outside person could reckon with confidence on attending to Varley's specification, not even the inventor himself. But Mr. Brush came afterwards and showed the means by which the end could be attained; and, according to the law as laid down by Lord Chelmsford, he was entitled to the invention, as his machine had been used since with invariable success. On the whole matter of law Mr. Jameson submitted that the Brush Company were entitled to a verdict in their favour on the ground that Varley's specification was not an anticipation by prior publication of the invention which was set forth in Haddan's or Brush's specification and letters patent. The next question, whether there was anticipation by prior user of the machine, must stand by itself apart from the specification altogether. Now, he thought it was quite settled law that anticipation by a similar but useless machine would not invalidate a patent. A subsequent patentee who invented a useful machine and gave the world the benefit of it, was not to have his rights taken away from him by some person coming forward who had invented a useless machine some years before, and was not able to make anything of it. Nor, again, would an experimental machine that had been set aside after trial invalidate a subsequent patent. It did not require that the machine should have been in use down to the time of the patent being brought forward. It would do if it had been regularly used and put to useful work, even if that use had been discontinued; but it must have been used in some way different from mere experiments. Varley never made a machine in which compound winding was practical; there was no user of it. He therefore submitted that Mr. Varley's machine was unworkable, and that there was no good ground for reduction of this patent of Mr. Brush's, which had been found so successful.

Mr. GRAHAM MURRAY, for the pursuers, said he would begin with the commutator, upon which the Lord Ordinary was in his favour, and consider the alleged discrepancies between the provisional and the complete specifications. He did not think there was any difference between them as to the law of the matter. He thought they were clearly at one that what must be disclosed in the provisional specification was the general nature of the invention, and what must be disclosed in the further specification was necessarily a sufficient way of carrying that out. But if he were able to show that the thing disclosed in the complete specification was a different invention from that in the provisional then the patent was bad. With regard to the commutator their lordships would also see that the divergence between the provisional specification and the final specification came to this, that all that was discovered, all that was claimed in the provisional specification, were mere mechanical improvements having to do with the circumstances of the commutator. They should take the commutator as a known thing, and they were giving a new mechanical construction to the commutator so that it would wear better. But when Haddan came to the final specification he had discovered something else, and that something else he claimed, and thereby the electrical efficiency of the machine was enhanced. In the original specification a disclosure was made of what might be called a mechanical construction of the commutator, and that alone, but in the final specification they claimed the insulating segments T, which were for the purpose of cutting armature bobbins out of circuit when they were crossing the neutral points. That was foreshadowing an invention that was not in any way disclosed in the provisional specification. Mr. Jameson had said that Mr. Brush had not claimed that this was a useful function, and that by the segments T they only claimed a mechanical arrangement of the commutator. That was not what Mr. Brush said. Mr. Murray then proceeded to point out the view that Mr. Brush him-

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self took of the matter. The only question, he said, which remained was whether there was any indication at all of this in the provisional specification. That there was a novelty in this cutting out of the armatures, if they excepted Varley, there was no doubt. No witness when he was asked to point out anywhere in the provisional specification a single passage or line that disclosed an invention by which this electrical result of cutting out the armature at a neutral point of the circuit was obtained could do so. The argument on the other side was not rested on the slightest attempt to show that the province of the insulating segment T was disclosed in the provisional specification. It was rather directed to try to prove that in the complete specification and claim Mr. Brush did not imply any such thing. But the person who must best know about it after all was Mr. Brush ; but Mr. Brush did not see the danger of giving evidence about this long before the proof that was taken in the Court of Session and before objection could be urged. At the same time it was clear that if it had not been for a defect in the original specification they should not have had the argument against it. Therefore upon this point he submitted that when the patent was looked at, and especially when the provisional specification was looked at, it was impossible not to see there was a meritorious invention in the complete specification and in the claim that was never adumbrated at all in the original specification.

The Court adjourned till next day.

FRIDAY, May 30th.

Mr. GRAHAM MURRAY, continuing his speech, said he should now like to say a few words upon the claim itself, and to show that it was impossible for his friends on the other side to urge that that claim was not for an electrical contrivance for having an insulating segment T. It was quite impossible for them to say that there was nothing but a claim for a mere mechanical contrivance. Therefore they tried to avoid it by enlarging the provisional and by lessening the final specification. Now claim 4 was for "a commutator having metallic insulating segments T, substantially as shown in division 3." That claim was nonsense, unless it was a claim for a segment T in its character of an insulating segment.

The LORD PRESIDENT : You say the point in which it exceeds the provisional specification is the insulating segments T ?

Mr. MURRAY : Yes, the whole stress being upon the "insulating." It was a curious thing to disclose that electrical advantage and have a claim appropriate to it, and afterwards to say that they did not mean to claim it. There were two answers to the reclaimers' view upon that point—first, that claim 4 would be useless, because they had already got it ; and, secondly, that suppose claim 4 were read as not a claim of an electrical advantage at all, but a claim merely of a mechanical arrangement, then it was not patentable, because the only patent would be making the insulating segment, which had been of wood, metallic. Therefore, he thought, he put his friends on the other side in a dilemma on that point. Another point he made here was that the other side always read "insulating" as if it were "insulated ;" but it was the power of insulating that was described and claimed, not something insulated. That was all he had to say on the discrepancy between the provisional and final specification ; but there remained the question whether Brush's commutator, as described in that specification, was not invalidated by prior use. Now, there were what were known as the Manchester, or Wilde's commutators. Evidence with regard to them he need not read, for this very good reason, that he did not think the other side contended that he had not perfectly well proved that these commutators were used. Their point, and the Lord Ordinary's point, was that these commutators were not proper anticipations. He then showed two of the Manchester commutators, one with and the other without wearing segments. These commutators were taken off the shaft, and the shaft itself was insulated from one-half of the commutator, and made to be in electrical connection with the other. That was to say, instead of having a pair of wires, as in Brush's commutator, the metallic shaft of the machine itself served the electrical purpose of one wire, and one wire only was brought into electrical connection with the other half of the commutator. That was the difference upon which the Lord Ordinary had gone. The Lord Ordinary said in his note that with regard to Varley's and the Manchester commutators, he thought it might be said "that they are cylindrical with metallic sub-segments, having metallic wearing segments, detachably attached. They also had an 'insulating body,' or substance. Yet with all these points of similarity I do not regard them as anticipations of the defenders' commutator. The insulating hub, or body, of the defenders' commutator is the 'body,' or basis on which his commutator is constructed, to which the various parts of this commutator are attached. This cannot be said of the Varley, or Manchester commutator, in which the insulating substance does not form the body or basis of the commutator at all, and insulates not the whole commutator, but only one section of it." Now, his lordship had made a slip there as regarded Varley's commutator. Varley's commutator was exactly like Brush's in the question of what parts were insulated, and what were not ; but with regard to the Manchester commutator, the Lord Ordinary was right. In answer to the Lord Ordinary, he had to quote the testimony of the witness Prof. Silvanus Thompson, who, speaking of the Manchester commutator, said :—"The use of the shaft in the machine as an electrical connection is a mere mechanical equivalent for a wire. It has been so used for a long time." Of course, if Prof. Thompson was right in that, then the converse of that was equally true—that the wire was a mere mechanical equivalent for the shaft. Therefore, that so-called electrical difference was really no electrical difference at all. It would not enable the other side to support a new patent if he had already discovered and used a commutator which had all the other parts exactly the same as Brush's ; simply because, finding a commutator which used the shaft as one of the means of electrical connection with the armature, and a wire as the other means, they substituted, therefore, two wires, and discarded the shaft altogether, the shaft being, of course, a very thick wire. He should like to put the matter in another way, which put the other side in a dilemma. If they were so particular as to deny that so far as that commutator was concerned there was any electrical discovery whatever, when he came to examine the Manchester commutator they must not say :—"True it is that your commutator is mechanically the same device, but electrically considered it works in rather a different way," because the communication was through the shaft instead of through a wire. Therefore, he submitted on all these grounds, Wild's commutator was an anticipation of Brush's. The Lord Ordinary made a slip with regard to Varley's commutator, he meant the commutator as made on Varley's machine. During the proof they got leave to take off some of it, and they could see the place where it was prised off. He showed to the Bench bits that had been taken off. The brass was "the sub-segment placed in electrical connection ;" the iron was "the wearing segment, detachably attached ;" and they could see the character of the little screw by which it was attached to the sub-segments His friends on the other side made this point that it could not be detachably attached when it required a hammer and chisel to take it off. It was true that it was taken off with a hammer and chisel under the inspection of Dr. Hopkinson ; but it must be remembered that nobody knew anything about that machine. It had lain in Siebe and Gorman's, and was covered with rust ; and, of course, they had taken off the commutator with a cold chisel and a hammer. The Court, however, would have no difficulty in coming to the conclusion that if it had been known that it was fixed in the way it was, there would have been no reason for hammering at all. All they needed to do was to cut a little nick in the head of the screw, put in a screwdriver and out with it. The only difference between the two was that while in Brush's the screw head was allowed to remain on, in Varley's the screw head was cut off, and the top of the portion left was hammered into a sort of a rivet. That finished what he had to say about the commutators. Practically it came to three points—disconformity between the provisional and the final specification, anticipation by Wilde's commutator by public use, and anticipation by Varley's commutator by public use. He now passed to the more general and interesting part of the case—the question of compound winding. There were two points upon that—publication by Varley and prior user in respect of Varley's machine. The real truth was that that invention was made for one purpose, and which, by an extraordinary piece of good fortune, was available afterwards for another purpose of infinitely greater importance. Whether Varley or Brush invented compound winding it was clear to demonstration that neither Varley nor Brush saw the real merit or real importance of the invention which they made ; and the great commercial value of the invention was due to something else entirely, which neither Varley nor Brush at that time knew anything about, and which was not discovered for some years afterwards. Until the great discovery of the incandescent lamp there was no use for a dynamo that would maintain constant potential ; but after constant potential became a necessity. It was provable to demonstration that constant potentiality was no part of Brush's purview at the time that he entered into that patent. Nay, more, it was proved that constant potentiality did not depend upon compound winding ; and although compound winding was a very convenient basis from which to start upon their search for constant potentiality, the true discovery of constant potentiality depended not upon compound winding, but upon certain other conditions altogether, which might really be got in a pure shunt-machine, just as much as in a compound-wound machine, and which if got in a compound-wound machine, depended not upon the fact that it was a compound-wound machine, but upon the proportion of resistance between the thickness of the two wires. What Brush really wanted was to secure a machine that would always have a permanent field ; in other words, that would maintain the passage of the electric current through the bath in the proper direction. Brush said, "other useful applications of a permanent field will readily suggest themselves ;" and it was upon these words that his friends upon the other side had now to hang constant potentiality. But there Mr. Brush himself forsook them ; for in his evidence in explaining the words "permanent field," he said they did not mean unvarying field, but a permanent field of unvarying polarity ; and again, "a field of constant polarity, and one not liable to reversal under normal conditions." But that matter did not rest there. He was glad and willing to take the other side's own witnesses, and no others, in support of his view. Prof. Silvanus Thompson said : "*Q.* Do you take it that the object of Brush's invention is to give a constant potential ? *A.* He never says so." Again, he said that "he thought that the success as to constant potential depended rather upon the conditions of the individual machine than upon the question whether it was series-shunt wound or shunt-wound ;" and again, that "he should have expected much more specific instructions than were given in Brush's specification if the patent had been one for constant potential." Further on he gives a piece of very cogent evidence to the effect that as soon as a suitable incandescent lamp was discovered, it became desirable to have constant potential, that a great many methods were tried, and that most of the devices were prior to the discovery of those conditions of proportionate resistance, and so on, which they now knew, and which ensured constant potential in a series-shunt machine. He called that most cogent evidence, because it showed that there was Brush with that very machine, compound wound if they liked, at the date when, a suitable incandescent lamp having been found, constant potentiality was desirable, and yet it did not occur to him or any one to solve the question of constant potentiality by means of compound winding ; because they tried some other plans. It was not until some one discovered "those conditions of proportionate resistance" that they were enabled to turn a simple series-shunt machine into one that would ensure constant potential. That was a most eloquent commentary upon any attempt to show that Brush had reached constant potential at the time he took out his patent. He thought he had shown that as regarded constant potential, the real merit of the invention was neither known to Brush nor to Varley. He now came to Varley's

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patent; and there the question was whether Varley did or did not disclose compound winding. His friends on the other side had tried to read, or rather to misread, Varley's specification by the light of another specification of Varley's, in 1867. He did not think that was legitimate in the construction of Varley's specification in 1876. Varley was the first inventor of a self-exciting dynamo, and it was that machine of 1867 that got a prize at the Electrical Exhibition. All reference to that machine ought to be kept out of this case. Coming, then, to Varley's specification of 1876, they found that Varley gave a description of his machine; and it would be convenient if their Lordships would follow the description of the models upon the Bench, because the cross-examination of the defenders' witnesses followed that line. Mr. Jameson had read the examination in chief of these witnesses, all of whom said the specification was misleading. He claimed to say that not one of them stuck to that position in cross-examination. They were forced to admit that the words there used were consistent, and consistent alone, with compound winding. Their Lordships, however, would, after all, probably be more inclined to take their own view upon that, than that of any of the witnesses; and, therefore, he asked their Lordships to follow with him upon the model the precise phraseology, and see how inapplicable the language was to any other way than compound winding. Mr. Murray then by aid of the models described the three methods of winding—series, shunt, and series-shunt; and proceeded to say that Varley described his method of winding thus:—"Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets." He paused there to say that that was evidently appropriate to describe either shunt proper or the shunt portion of a series-shunt machine, because in both it was true that part of the electricity was diverted to maintain the magnetism of the magnets. "And the remaining portion is used to produce the electric light." Now, said his friends on the opposite side, "You must read in these words 'is only used to produce the electric light,' because, as a matter of fact, in a compound-wound machine, the remaining portion of the electricity is used not only to produce the electric light, but also to maintain the magnetism of the magnets." Leaving that over in the meantime, he went on, "There are several well-known ways of doing this, but the method I prefer is to wrap the soft iron magnets with two insulating wires, one having a larger resistance than the other." He paused there again, for here was the bottom of the fallacy upon which the defenders' witnesses proceeded. There were two ways in which the sentence grammatically could be read. One was:—"There were several well-known ways of doing this, but the one well-known way I prefer is so and so." All his friends' witnesses started by reading it in that way, and they said triumphantly that the only well-known ways were ways that did not include compound winding. But the other way in which the sentence could be read, and his way of reading it, was:—"There are several well-known ways of doing this, but I show unto you a more excellent way, which is wrapping the two magnets with two wires." Grammatically speaking, he was free to admit there was nothing to choose between the two, the use of the disjunctive "but" being equally appropriate.

The LORD PRESIDENT: There is a change in the word "way." He uses "method."

Mr. MURRAY said that was in his favour. He did not think any one had seen that hitherto, and he thanked his lordship for pointing it out. What was Varley's method? He wrapped the soft iron magnets with two insulating wires, one having a larger resistance than the other. It seemed to him perfectly clear that that sentence put out of the way either pure series or pure shunt; and for this reason—why have two wires when you only need one? They did not need to wrap the two magnets with two wires unless they were going to pass a current through them. There was a wild attempt on the part of Mr. Preece to represent that that might be done for the induction purposes, but he had to discard the attempt. But then came a very important sentence, "The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light." That was perfectly appropriate to series-shunt. His friends on the other side wanted to read in the word "only." That necessitated them to say that that was pure shunt, because the circuit of less resistance was used, not only for the electric light, but also for the magnets. But then the next sentence drove them from their position:—"When the electric light is being produced, the greater portion of the electricity passes through the circuit of less resistance, which I term the electric light circuit, maintaining the magnetism of the magnets and producing the light." That clinched the whole concern, because it just left out the word "only," which his learned friend wanted read in. It would not be true, and could not be true of a shunt arrangement, because in a pure shunt arrangement the circuit of less resistance is maintaining the magnetism of the magnets, and therefore they could not read that sentence as consistent with any method of arrangement except compound winding. "When the electric circuit is open from any cause, the electricity developed passes through the circuit of greater resistance only," that was to say, the shunt, "and maintains the magnetism of the magnets." How very clear all that became if they substituted the word "shunt" for "the circuit of greater resistance." Having read the specification in that way, he said that nothing could be clearer or plainer than that, and he never saw in his life a more absolutely unscientific spectacle than the defenders' witnesses presented in deliberately sitting down and determining not to understand the thing, in order to avoid the one conclusion to which in the end they were forced, namely, that that was series-shunt winding, and nothing else.

LORD McLAREN: I suppose we must take it that the self-excitation of the magnets by the machine was known at the date of this specification, although not widely known?

Mr. MURRAY: Yes.

LORD McLAREN: The only question between you is whether this passage, which undoubtedly describes one form of compound winding, describes compound winding in which the wires that go round the magnets receive their electricity from a separate source or from the same source. There is no direct indication of a separate source.

Mr. MURRAY said he should be able to read evidence that would utterly drive separate excitation out of the question. He wanted first of all to show that the defenders' witnesses were really forced in the end to admit that his was the only clear construction. His point upon Varley's description was this, that if the blindest workman in the world did what Varley told him he would have compound winding in spite of himself.

LORD McLAREN: What is the criterion you propose to apply to the interpretation of the specification? Must it be so clear that a workman of ordinary skill would understand it, or would this be sufficient that this particular part of the specification would enable a person already familiar with dynamo machines as known at that time to add compound winding to the other requisites?

Mr. MURRAY: I do not think honestly that there will be much between us in the law. I am quite willing to take it as already laid down by the Bench. But it is difficult to make an exact definition of these sort of things. Certainly an anticipation necessarily is an anticipation which fairly discloses the invention, and discloses it in a way that is understandable by a person well versed in the science.

LORD McLAREN: A person who knew dynamo machines as then existing.

Mr. MURRAY: Certainly, and a person of great intelligence. But while that was so, he submitted that a very stupid person would have understood that specification of Varley. Proceeding to deal with the evidence, he said he wished to take the defenders' witnesses, and to show how, in cross-examination, they had been dislodged from their position. They all commenced by saying that Varley's description meant series, or shunt, or separate excitation; but he had made them confess that the words were inconsistent with shunt, with series, or with separate excitation, and that there was nothing left but series-shunt. Mr. Murray then read from the evidence of the defenders' witnesses, Profs. Silvanus Thompson and J. Perry, Sir William Thomson, and Mr. Preece, to prove what he had just said. Mr. Preece had, he said, gone into the box very confidently, holding the view that the whole thing was inconsistent with series-shunt; but when he was pressed he admitted that it was not so. He was pushed from one corner into another, and then when he was floundering—if the term might be used without rudeness—he seized upon the idea of double shunt only to abandon it. He need scarcely say that as regarded the pursuers' witnesses their evidence was clear and distinct in the view that it was compound winding, and their testimony was unshaken in cross-examination. Mr. Murray next referred to some matters of criticism that here and there had crept up in the defenders' case. Those with which he would deal were the use of the word "divert," the use of the word "circuit," and the question of "bifurcation." With regard to the word "circuit" the witnesses said that the term accurately used meant circuit from end to end, and that no one ought to speak of "series circuit" or "shunt circuit," that being technically incorrect. That might be, but nevertheless Brush himself, and several of the witnesses themselves, fell into these very inaccuracies. With regard to "bifurcation," it had been suggested by some of the witnesses that bifurcation was necessary, as of course it was, in that arrangement, and that nothing was actually said about bifurcation in Varley's patent. Sir William Thomson disposed of that perfectly satisfactorily; for he said, in his evidence, that birfurcation of an electric current by splitting a wire was not beyond an electrical workman, and that if he found it necessary for any reason to bifurcate his current, splitting the wire would readily suggest itself. Coming to the question of whether separate excitation was part of Varley's patent, he said he would explain the part of the patent which enabled him to put out of the way separate excitation altogether. There were certainly two plans which helped them to do that, and one of them was exceedingly strong and utterly inconsistent with separate excitation. He quoted from Varley's specification as follows:—"The number of bobbins in each group may be two or four or eight; the number of commutators employed may correspond to the number of bobbins forming the group, or they may be increased in number; and when electricity of a very high potential is desired, the commutators may be increased to the same number as the bobbins." Then, at another part, Varley said: "When the number of commutators correspond to the number of bobbins forming a group, the ends of the insulated wires of each group are joined side by side to the respective discs of the commutators." Varley went on to say: "The springs which rest against the commutators are so connected as to form a continuous electrical circuit from one to the other, through the metal discs of the commutators." Their Lordships would see that that was absolutely destructive of the idea of separate excitation from a separate portion of the armature, because, if they had separate excitation from a separate portion of the armature, they must have that separate portion commuted by a separate commutator of its own, and of course taken away to the magnets; whereas the rest of the electricity developed by the armatures would be commuted by its commutator and taken away to the circuit. If they put these two commutators in direct electrical connection, they destroyed the whole thing. Therefore, inasmuch as there was only one method of winding given, the patentee was of course entitled to wind any machine which had been previously described by that method of winding, and he proceeded to compound wind a machine which had a commutator of such a construction that separate excitation was impossible. In support of that contention, he quoted the evidence of Sir Wm. Thomson Profs. Perry and Silvanus Thompson, and Mr. Preece, the defenders' witnesses, and Mr. Swinburne and Prof. Ewing, the pursuers' witnesses. Dealing with what counsel on the other side had called "electrical absurdities" in Varley's patent, Mr. Murray said Sir Wm. Thomson said that Varley had a wrong theoretical idea, which resulted, after one of the armature bobbins was cut out of a certain portion of the revolution, in throwing in the bobbin again too soon. That was exceedingly temperately put; but one of the great peculiarities of electrical science was this, that although these gentlemen had discovered a great deal in one way, they had discovered uncommonly little in another. In fact, electrical

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science, in one sense, was still entirely an empirical science. Assuming that Varley was wrong when he went a little beyond his province and described in his patent the way in which electricity was formed and magnetism was stored, it did not make any difference in his machine, except what Sir William Thomson said about leading to the bobbin being thrown in too soon.

The LORD PRESIDENT: We are not trying the validity of Varley's patent, but only what it disclosed.

Mr. MURRAY: Certainly. But there was another matter to which he would ask their Lordships' attention, and that was what Prof. Silvanus Thompson said, that "Varley's machine, such as it is, works or does not work quite irrespective of the theory on which it is constructed. The machine described in the specification is a workable dynamo machine, and at its date I do not know that there were any better." The machine which defenders' counsel wished to make out as a failure was described by their leading witness as one which at its date had no rival. Of course, the machine was a failure if they pitted it against the machines of the present time; but at its date it was a good machine, and in this question of anticipation it could not be described as a failure. But passing from that, there was a very good reason why Varley should have been anxious to introduce that compound winding. He had already admitted, as part of his argument, that Varley did not know that he was laying the foundation of constant potential; but he did know that part of his patent was concerned with a lamp, and the lamp which Varley constructed was a lamp for the proper working of which it was almost necessary that he should hit upon compound winding. The learned counsel described the lamp which Varley's machine was made to work, and gave reasons to show that it could not have been worked either by pure series or by pure shunt; but that the difficulties experienced by either of these methods were avoided with series-shunt. In support of his view he quoted the evidence of Mr. Swinburne, and Profs. Ewing and Silvanus Thompson. He would pass to another branch of the case, which his friend Mr. Jameson did not touch upon, but which he submitted could not be treated so cavalierly. He referred to the fact of that compound winding having been reached through Varley's specification by no less than four mechanics. The models made by these apprentices from Varley's specification varied in form, but they were all equally compound wound. He did not say that it was conclusive, but it went a long way to show that the description in Varley's patent was not the terribly difficult thing to understand which some of the witnesses on the other side said it was. He proceeded to deal with the question of disclosure by prior use by the machine made under Varley's directions by Siebe and Gorman. That machine showed that it had got two windings round the magnets, and his friend could not deny that it could be perfectly easily used as a series-shunt machine.

LORD McLAREN: Have you evidence that it was in fact used as a series-shunt machine coupled up in that way?

Mr. MURRAY: I have got very good evidence of two sorts. It was used publicly to illustrate certain operations in a diving tank, and for the purpose of photographing an ice machine. They were not experiments on the machine itself. He quoted the authority of several cases with regard to what public use really was.

LORD McLAREN: Your point is that it is enough if the results are shown to the public, although no one can see how the thing is done.

Mr. MURRAY: Exactly so. If you put a book in a bookseller's window, that undoubtedly is good publication in the sense of the law. He went on to say that there was very good evidence to show how that machine was connected, in the sketch made by Varley in an old note-book. Sir William Thomson, looking at Varley's sketch, said it was series-shunt. The date of the sketch was about the date of the specification. There was another piece of evidence which showed quite distinctly that the machine was coupled up in series-shunt. A common workman who did not know anything about these matters, and could not explain the operation of compound winding, and therefore could not have been coached, gave evidence which showed how the machine was used. He quoted from the testimony of Edward F. Myers to show that certain results which he had noticed when Varley's machine was in operation could have been produced only by a machine coupled up in series-shunt.

LORD McLAREN: I think one can hardly doubt that that machine of Varley's was compound wound, although one cannot say whether it was a good one.

Mr. MURRAY: That is so; but it does not much matter; and the question of its being conceivably double-shunt, as Mr. Preece at one time said, is put out of the way, because if it was double-shunt the lamp must necessarily have had a key, and there was a joint minute put in stating that there was no key ever used with that lamp. He concluded by submitting that the Brush patent was bad, upon the various grounds which he had adduced.

At the close of Mr. Murray's speech, the further hearing of the case was adjourned till Tuesday.

TUESDAY, June 3rd.

The DEAN OF FACULTY (Mr. J. B. Balfour, Q.C., M.P.) addressed the Court on behalf of the defenders and reclaimers (the Anglo-American Brush Company). Dealing in the first place with the mechanism of the commutators, he addressed himself to the alleged disconformity between Haldan's final specification and the provisional specification, and argued that the Lord Ordinary, in giving judgment in the Outer House, had lost sight of the respective functions of a provisional and a final specification. His (counsel's) contention was, that the purpose of a provisional specification was merely to mention or disclose the nature of the invention. It was in the later and final specification that the particular details and the mode of carrying out the specification were given. The object of a provisional specification was to enable a man when he had got hold of a novel and useful idea to work it out during the six months' protection afforded to him. The Dean next proceeded to point out that Brush claimed a peculiar form of commutator, which combined cylindricity, durability, and repairability; and it was evident that the insulating segment T was within the general description and purview and aim of the provisional specification. The Lord Ordinary was with him (the Dean) upon the next question, namely, whether Wilde's or Varley's commutator was an anticipation of Brush's. No doubt in Wilde's commutator the shaft was used as an electrical equivalent for a wire; but Brush's commutator claim was for a combination, and while in Wilde's the shaft was an electrical equivalent for a wire, it was only for one wire, and could only work with an armature with one bobbin, in Brush's they could have as many rings of segments as they liked, and adapt it to the superior work that had now to be done. Another difference was that while in Brush's they had an insulating hub, in Wilde's, with the shaft doing electrical work, they would have considerable leakage of electricity, seeing that the shaft was in connection with the iron framework of the machine. Therefore, Brush was superior to Wilde in that respect. Then again, comparing Brush's with Varley's commutator, while in the former the wearing segments were detachably attached by means of a screw, in the latter they had to be broken off with a cold chisel or crowbar, with the result that the machine was damaged. Further, comparing Brush's method of attachment—a screw, with Varley's—a nail or rivet, the advantage was all on the side of Brush. No doubt, Varley's came very near Brush's with regard to the mechanism combination; but it did not satisfy either the description in Brush's specification, or the advantages claimed for it. He now passed to the question of compound winding. Mr. Murray had said that neither Varley nor Brush knew of the advantages, or the material advantages of compound winding at the date of their patents. Mr. Murray could not dispute that there was in Brush's publication a full, complete, and clear disclosure of compound winding, nor could he dispute that, until Brush made that invention in 1878, compound-wound dynamos were never even used or in the market. Now there were thousands of them; and whether or not Brush was anticipated by Varley, it was Brush and not Varley who had made that mechanism useful to mankind. While Brush's machine had become a world-wide success, Varley's—which was an experimental machine—was stowed away among rubbish in Siebe and Gorman's, and was never heard of, until it was resuscitated for the purposes of the Crompton case. While it might be true that Varley did not appreciate the value of his invention, it was not true of Brush, because Brush in his specification showed by his description that he appreciated what he invented. Mr. Murray's point was that there was no incandescent lighting at that time. No doubt there was very little; and while Brush might not have seen what fine measures of adjustment might ultimately be required to secure constant potential, he certainly devised and executed a mechanism which necessarily could not help making a very near approach to constant potential, and which did make as great an approach to constant potential as appeared to have been necessary at that time for electro-plating. Comparing the obscurity of Varley's specification with the clearness of Brush's, the Dean said that the reason why Brush succeeded was that he drew up a proper specification and went into the market with his completed machine. They got some light on the matter from Varley's own evidence. There was no doubt he was a man of great ingenuity, but without the staying power to work his ideas into practical form. While he seemed to have visionary or floating ideas they could not be practically put together. Varley seemed to have launched this general description, and then proceeded to see whether it would work. Although there might be dangers attached to experiment, they were certainly not those dangers of first adumbrating something in writing and then trying if it would work. The trial in this case proved that it would not work; and although 14 years had elapsed since then, no machine, except that which was taken from Siebe and Gorman's yard, was ever made, and no machine ever succeeded. The Dean then proceeded to contend that it was not enough to take a few lines of a patent and say that because they were not inconsistent with compound winding, then compound winding was disclosed. Before a thing could be a disclosure of a machine, it must direct a man how so to make it that he would be certain of the result. He was not merely to get a description of a thing consistent with one thing which might be consistent with a dozen other things. He must get a description which marked out one machine from all others. While there were some lines in the specification which might be extracted out of this description which would be consistent with compound winding, yet he disputed that consistent and description were synonymous terms. Then, again, a great peculiarity of this case was, that if Varley should prove to be the inventor, after having got an enormously valuable invention, he did not claim it. Varley stated, with regard to the winding of the magnets, there were several well-known ways of doing this, but the method he preferred was to wrap the soft iron magnets with two insulating wires, one having a larger resistance than the other. The circuit of larger resistance was always closed, and the circuit of less resistance was used for the electric light. It was said that here they came nearer to compound winding. It was said that the previous two lines he had referred to described compound winding; and now Varley proceeded to say that there were well-known ways of doing this, that there were well-known ways of compound winding at a time when it had never been known. If an ordinary workman of that time had been started on this wild-goose chase by being told to separate the total electricity into two parts, and then was informed that there were several well-known ways of doing this, what would he do? He would look to his common knowledge to see where were the several well-known ways of doing this, and he would think of the ways which were all inconsistent with compound winding. Varley went on to describe something which he (the Dean) did not dispute might be consistent with compound winding. What he said as to the method he preferred, of wrapping soft-iron magnets with two insulating wires, one having a larger resistance than the other, up to a certain point was concerned with compound winding, because they had in compound winding

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soft-iron magnets, wrapped with two insulating wires, and one had a larger resistance than the other. They had a shunt wire with a large resistance, and a series wire with a small resistance. But they were not told where those wires came from, and how they were coupled up. They might have come from the armature, and they might have come from the outside altogether. Varley told them that there were some well-known ways of doing it, but no human being had ever done it in this way before. Then it would not do to extract a line out of the specification at one place and another line out of another place, and a third line out of a third place, and putting them together say that meant compound winding. That did not constitute a clear and definite instruction, according to which a workman of the year 1876 would be able to construct the machine. The only other point he had to deal with was regarding the machine which was constructed in Siebe and Gorman's yard. The people there were skilled mechanicians, and they had every advantage; but yet they never got beyond the point of experiment.

At the conclusion of the Dean's speech the Court rose for the day.

WEDNESDAY, June 4th.

Mr. DICKSON replied for King, Brown, and Co. He said that with regard to compound winding, undoubtedly Varley, like Brush, was before his time in the discovery, and the reason why Varley had not followed out the patent of compound winding was, in the first place, because he had not funds, his partnership with Siebe and Gorman having broken up; and in the second place because he thought if he claimed compound winding he would endanger the patent he had, seeing he was apprehensive that his brother, Cromwell Varley, whom he thought had already found out compound winding, would interfere. Varley's scheme was distinctive enough; for, while its main purpose was to produce the electric light there were statements that it might be useful for other purposes. With regard to Varley's machine, he said that it had been publicly used in Siebe and Gorman's. It was worked there and people came to see it. It was worked to make experiments in a diving tank; and that was surely anticipation by prior use. Varley had in view compound winding when he had that machine constructed.

At the conclusion of Mr. Dickson's speech, the Court took the case to avizandum.

Crompton and Co. (Limited) v. the Elieson Electric Company (Limited).

In the Queen's Bench Division of the High Court of Justice, on Thursday, the case of Crompton and Co. (Limited) v. the Elieson Electric Company (Limited) came before Mr. Baron Huddleston and a special jury. This was an action brought by the plaintiffs, Messrs. R. E. Crompton and Co. and Messrs. Crompton and Co. (Limited) to recover £454 odd for goods sold and delivered and work done between May and November, 1888. The defendants admitted the plaintiffs' claim, subject to a reduction of £70. They, however, counterclaimed for damages laid at £10,000, for injury to their business and reputation, caused by the alleged negligence of the plaintiffs.

Mr. F. Moulton, Q.C., and Mr. Graham appeared for the plaintiffs; while Mr. Finlay, Q.C., and Mr. Bousfield represented the defendants.

The defendants having admitted the claim of the plaintiffs, subject to a deduction,

Mr. FINLAY opened the defendants' case in support of their counterclaim. He said the defendants had a large claim against the plaintiffs for the negligent way in which they conducted and superintended the working of certain electric engines. The defendant company was formed in June, 1887, for the purpose, *inter alia*, of providing traction by means of electricity, and it took over the business and the rights vested in a preceding Company known as the Electric Locomotive and Power Company, which had an arrangement with the North Metropolitan Tramways Company for supplying electric engines for the purpose of drawing tramcars over a part of the line from Stratford to Manor Park. These engines were used experimentally with the view of their being run over the entire section of the line between Manor Park and Stratford, and at other places. Under contracts existing in May, 1888, the North Metropolitan Tramways Company were paying the defendants large sums for the use of the electric engines, for the maintenance and repair of which the defendants had erected extensive works and buildings at Ilford, Essex. In July, 1887, there had been something wrong with the armatures of the motors, and the plaintiffs were called in to supply fresh armatures. This they did; and up to March, 1888, the system of locomotion with which the name of the defendant company was identified was perfectly successful. In March, 1888, the defendants were desirous of enlarging their operations and providing more engines, and undertaking the whole of the tramway service of the North Metropopolitan Company, and for that purpose larger works were constructed. The defendants proposed to utilise works at Plashet Hall, and Messrs. Crompton suggested that they should be entrusted with the construction and superintendence of these new works. On the 8th of May it was agreed that they should be responsible for the sole management of the works and the running of the engines on the line, the defendants giving them a weekly cheque for expenses and wages of the men. Everything the plaintiffs wanted was provided and paid for by the defendants. The superintendence of the plaintiffs continued from May until September, 1888, when there was a series of serious breakdowns. The Tramway Company had been running their cars by horses during the time the defendants were getting the engines ready; and on the 5th of September, at the plaintiffs' request, defendants wrote to the Tramway Company to the effect that the electric engines would be ready to resume running on the 18th of that month. On the 10th, 11th, and 12th of September serious accidents occurred. In the first place, the plaintiffs sent out engines insufficiently stored with electricity, and consequently the tramcars stopped short in busy streets, where the traffic was great. Secondly, they did not leave the points connecting the siding with the main line, and consequently the wheels of two of the engines were broken. Thirdly, through a mechanical defect, the rack of one engine was broken. The plaintiffs were solely responsible for these accidents; but the result to the defendants was that on September 13th the North Metropolitan Tramways Company ordered the running of the cars by electricity to be discontinued. Consequently the defendants lost the profits of their contract with the Tramway Company, their works at Ilford were rendered useless, and their reputation as providers of traction by electricity had been greatly damaged by the negligence of the plaintiffs.

Mr. THOMAS BRYCE GOWER, secretary of the Elieson Electric Company, went into the witness box and gave evidence, bearing out Mr. Finlay's statement, and was still under examination when the Court adjourned.

REPORT OF THE FRANKFORT ELECTRIC LIGHTING COMMITTEE.

The following is an abstract of an interesting Report of a Committee appointed last autumn by the Town Council of Frankfort-on-Main to deal with various matters in connection with the question of electric lighting. This Committee, which consisted of Profs. Galileo Ferraris, F. Uppenborn, H. F. Weber, Kittler, and Herr W. H. Lindley, reported on the subject of alternate-current motors, transformers, arc lamps, and meters, and discussed at great length the advantages and disadvantages of various systems of supply. The results of some experiments which were undertaken by this Committee to test the efficiency and capabilities of the Ganz alternate-current motor were published in *The Electrician* of March 7, 1890, p. 453.

Alternate and Direct-Current Arc Lights.—In order that the lighting effect of arc lights fed by the two systems might be tested, the Corporation built two exactly similar rooms, provided with windows on the north side only. In one room was a Schuckert direct-current lamp, and in the other a Ganz alternating-current arc lamp. Both lamps were placed at the same height and consumed equal amounts of energy. The five members of the Committee each observed, from outside, the illumination produced on the three sides, the ceilings, and the floors of the two rooms. In the result, it appeared that the illuminating effects of the alternating-current lamp and the direct-current lamp were as 1 : 1·23. For out-door illumination, all the observers agreed in putting down the illuminating power of the alternating-current as less than that of the direct-current, in the proportion of 4 to 5. It was proved that the alternate-current lamp required more amperes than the other; but it also appeared that if the total radiation was taken into account, and not only that portion of it that was directed towards the earth, the ratio of the lights was as 4 : 3. It appeared that the maximum illuminating effect of the alternate-current lamp was not, as frequently stated, in a horizontal direction; but that two cones of maximum illumination existed one above the other below the horizontal. The Committee reported, therefore, that equal amounts of energy gave 20 per cent. less useful lighting effect with the alternating-current both for outdoor and indoor lighting. On the other hand, the alternating current lamp required a lower tension, and a smaller resistance for regulation, and could consequently be run with 20 per cent. to 30 per cent. lower voltage; so that three of them could be run in series off a 105-volt circuit, instead of only two in the case of the direct-current lamp. The Committee reported that the buzzing noise observable with alternating currents was quite unimportant, as there was always a slight hissing even with direct-current lamps. The consumption of carbons was found with equal energy to be 20 per cent. higher in the alternating-current lamps; but as the cost of the carbon in 6 to 12-ampere lamps is only 10 per cent. of the total, this only means an increase of 2 per cent. on the whole cost. It was found that the cost of an 8-ampere alternating-current lamp was from 2·8 pence to 3·5 pence per hour, this size giving the same amount of light as a 6-ampere direct-current lamp costing 2·25 to 2·8 pence per hour; the larger sizes, taking 16 and 12 amperes respectively, cost from 5·2 to 6·5 pence in the case of the alternating-current lamp, and 4·1 to 5·1 pence in the case of the direct-current lamp. It was remarked that the alternations of current gave a multiple impression of objects in rapid motion, though on fixed objects the alternating-current light seemed perfectly steady.

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Alternate-Current Meters.—Tests made with the Blâthy alternate-current meter showed that the instrument was correct within 3 per cent. for currents within the limits for which it was designed. In point of simplicity, size, cost, and sensibility it fulfilled all reasonable demands.

Alternate-Current Transformers.—The Committee reported that some tests undertaken by them showed that the efficiency of the Ganz medium-sized transformer was at full load 95 to 96 per cent., at half-load 93 to 94 per cent., at quarter-load 90 per cent., at one-eighth load about 80 per cent.

Direct-Current Transformers.—The Committee reported that they were not acquainted with any direct-current transformer that would answer the requirements of a central station. They could not recommend that which had been first proposed by Schuckert, and afterwards by Lahmeyer, in which both windings were on the same ring. They regretted that they had had no opportunity of testing such a transformer. The question of cost was not gone into, as none of the systems proposed for Frankfort involved the use of a direct-current transformer in the same way as the alternating-current schemes. The Committee called attention to the fact that the direct-current transformer, unlike that for alternating currents, contained moving parts, and therefore required constant attention. The efficiency of the direct-current transformer when working with full load was found to reach the 82 per cent. claimed for it by Messrs. Schuckert and Co. For less than full load the efficiency was not a matter of importance, as it was intended to use the transformer always at full load to charge accumulators. The loss on alternate-current transformers was only 5 or 6 per cent. as compared with this 18 per cent.

Accumulators.—With reference to accumulators, the Committee were asked whether any cell could be recommended for use on a large scale. Although on other questions they had been unanimous in their decision, on this point there were differences of opinion. Prof. Ferraris remarked that with regard to accumulators he had always been a pessimist. There had been numerous attempts at improving secondary cells, which proved the importance of the question ; but up to the present all expectations had been falsified. The Tudor accumulator gave good results on account of the method of making the plates, but this very process made it probable that they would completely break down after a time ; and he considered that a longer experience was necessary before deciding on its degree of merit. He did not consider that any system embracing so doubtful an element was to be recommended. Prof. Weber said that from the experience of the last few years he considered the lead accumulator had not improved much in efficiency. As regarded the life of the new Tudor cell, he thought an improvement had been effected in this direction, but it was impossible to say to what extent, as only two years' experience was obtainable, and from this no deductions could be made as to their probable state after ten years, the time for which the Company gives guarantees. He considered it a step in the right direction that Müller and Einbeck, of Hagen, undertook the maintenance of the cells. He would be pleased to see an accumulator plant installed at Frankfort, as it would afford an opportunity of watching the behaviour of accumulators employed on a large scale. Direktor Uppenborn did not see that the town would incur much risk, as the surplus of the subscribed fund could be applied to maintenance. He considered that all that was known of the action of the lead plates proved that their life would be sufficiently long. Prof. Kittler agreed with Direktor Uppenborn, but said he should have reported against the adoption of accumulators until the production of the Tudor type, which he was convinced showed great progress. He had proposed the use of accumulators for running machinery to the authorities at Darmstadt, where they had been working satisfactorily. He thought the substitution of wood for glass cells was an improvement, doing away with many chances of accident. He considered, therefore, that a town in using accumulators ran no risk either from a technical or a financial point of view.

The Five-Wire System.—As to the applicability of the five-wire system, the Committee reported that the first scheme of Siemens and Halske was not satisfactory, but that the second was more likely to satisfy requirements. As to the proposed tension of 440 volts, the Committee reported that the use of so high a voltage would necessitate great care on the part of the attendants. A disadvantage of the system was that the five distributing mains would each have to be laid separately, as under no circumstances would it be advisable to make up all the leads into one cable. Moreover, to ensure good regulation, it would be necessary in most cases to connect all five cables with customers' houses, which would be expensive. The Committee, however, stated that all these disadvantages were not so vital as to exclude the five-wire system where other circumstances rendered its adoption advisable.

Electric Traction.—With regard to traction, the Committee regarded a direct-current supply with overhead wire as out of the question for Frankfort ; an underground channel would therefore have to be used. If the traction current was supplied from the same circuits as the lighting current, the result would be a very bad effect on the lighting, owing to the variation of the demand for current for traction purposes at different times of the day and seasons of the year. This would be greatest on the winter evenings, just when the light was most required. For financial and practical reasons, it would, therefore, be well to separate the lighting and traction mains. It would, however, be advisable to adopt in each case the same class of current and the same voltage, so that in cases of accident interruption might be guarded against. For this reason both circuits should be worked from the same central stations. If the five-wire direct-current system were adopted, the pressure would suit traction work. If transformers (direct-current) were used, a subsidiary station could be employed. If the alternating-current was used, the traction systems might be supplied either from the exciting dynamos, or by means of transformers, using alternate-current motors. If, however, improvements in accumulators should warrant it, they would afford the surest and most satisfactory solution of the difficulty. It was concluded, therefore, that either system would serve equally well for the traction service.

Current for Electro-Chemical Purposes.—On the subject of distribution for electro-chemical purposes, the Committee reported that the demand for this was comparatively small, and that, the voltage required being very low, even with the direct-current system, a transformation would be necessary, so that the alternate-current and direct-current systems were in this respect on an equality.

On the whole question as to which of the two systems was to be adopted at Frankfort, the Committee found it difficult to arrive at a definite conclusion, owing chiefly to the fact that the suitability of this or that system depended largely on where the central station was to be, and whether water-power would be available ; and neither of these matters were then settled.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 23, 1890.

The Meeting of the American Institute of Electrical Engineers.—The event of the week on this side of the water has, of course, been the meeting of the American Institute of Electrical Engineers, which took place partly in New York and partly in Boston on Tuesday and Wednesday respectively. The annual business meeting was held in New York on Tuesday evening for the election of officers and the transaction of routine business. Prof. W. A. Anthony, of Manchester, Connecticut, was chosen President in place of the retiring Prof. Thomson, and Messrs. Francis B. Crocker, Frank J. Sprague and Joseph Wetzler, vice-presidents. The other officers chosen were as follows:—Managers: P. B. Delany, Horatio A. Foster, and J. C. Chamberlain; Treasurer: George M. Phelps; Secretary: R. W. Pope. The other officers of the Association hold over. It was reported that the total membership of the Institute is now 427, of which 12 were added at this meeting. At the New York meeting a Paper was read by Mr. Gilbert Wilkes upon "Electricity in the Navy," which gave considerable insight into the conditions necessary for electrical machines in naval service. At its conclusion many of the members of the Institute took the night train for Boston, where, on Wednesday morning, the meeting was continued in the building of the Massachusetts Institute of Technology. The Institute was welcomed by General Walker, who said that the Institute of Technology had felt it a privilege to entertain the mining engineers and other professional organisations, and that he was now glad to find electrical engineers as numerous and as welcome guests. Prof. Thomson responded on behalf of the Electrical Institute, after which the regular programme for the day was taken up. The first Paper was by Mr. Wilfred H. Fleming, of New York city, upon "Electric Lighting in the Tropics;" and the second upon "The Magnetic Data of the Sprague Street Car Motor," by Mr. H. F. Parshall. Dr. Louis B. Marks, of Cornell University, then discussed "Arc Light Carbons." Perhaps the most important Paper of the meeting was that upon "The Limitations of Steam and Electric Transportation," by Oscar T. Crosby, of New York city, which opened the afternoon session. Mr. Crosby has recently given some extremely valuable data concerning "Atmospheric Resistance

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at High Speeds in Railway Traction;" and his present Paper, like that referred to, is the result of a long series of experimental tests in practical railroad work done under the auspices of the Weems Electric Railway Company. He spoke most encouragingly of the prospect of replacing steam by electricity, not merely upon city lines and for light work, but also for the most important uses to which railroading is now applied. His tables while conservative were elaborate and thorough, and show that the economical line dividing the present practice from that of the future is becoming so slight that electrical traction may soon be expected to replace steam on all important railroads. Other Papers read in the afternoon were by Dr. Michael J. Pupin on "The Practical Aspects of the Alternating-Current Theory;" by Mr. Thomas D. Lockwood, of Boston, on "The Industrial Utilization of the Counter Electromotive Force of Self-Induction;" and by Mr. Herman Lemp, Jun., on "Automatic Electric Welding Machines." Mr. Lockwood's Paper was historical in its nature and of very great interest, while Mr. Lemp's was accompanied by some extremely valuable experimental demonstrations. In the evening the Institute was sumptuously entertained by the Boston Electric Club at a dinner. Seven long tables were occupied by the members and guests, and no more noteworthy gathering of electricians has been seen in this country for a number of years past. After the dinner Mr. S. E. Barton spoke upon "The Relations of Electric Lighting to Insurance," and demonstrated to the satisfaction of those present that these relations should not be so strained as they at present seem. Other speakers were Prof. Thomson, Prof. Houston, Prof. Anthony and Mr. Pope; while Mr. C. F. Pritchard, President of the New England Association of Gas Engineers, extended the hand of friendship on behalf of the rival interests represented by him. Mr. Joseph Wetzler responded on behalf of "Electrical Journalism," and Senator Metcalf promised the goodwill of politicians and statesmen. On Thursday the Institute accepted the hospitality of various Boston electrical enterprises, and visited the power plant of the West End Tramway Company, one of the largest of its kind in the world, and also the great manufacturing works of the Thomson-Houston Electric Company at Lynn, near Boston. The meeting, although officially concluded on Wednesday, thus continued throughout the next day, and the interchange of ideas and informal discussion of Papers during the trips about town on Thursday form one of its most valuable features. It can safely be said that the experiment thus tried of holding a meeting of the American Institute of Electrical Engineers outside of New York city was eminently successful; and if the metropolis is to re-assert her claim to leadership in electrical matters she must look to her laurels next year.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *June* 4, 1890.

The Compagnie Continentale Edison has doubled the number of arc lamps lighting the Boulevard des Italiens, but the new lamps have not been placed in the middle of the road, as the old ones were, but have been arranged along the edge of the pavement. The lamp-posts are very handsome, being of the pattern adopted by the City of Paris for its large gas-burners. Owing to this new arrangement, the lighting of the Boulevard des Italiens is very brilliant; but these successive additions do not give so good a result as would have been the case if the installation had been completely planned at the outset.

The Société de la Transmission de la Force is actively pushing forward the work of laying underground mains. It is also making arrangements to place arc lamps along the pavements of the Boulevard Sébastopol, from the Boulevard Saint-Denis to the Rue du Caire.

The trials with the Cohen smoke-consuming furnaces, undertaken about five months ago at the Palais Royal central station, have proved very conclusive. The emission of smoke was very slight, and the consumption of coal was reduced by 20 per cent. These furnaces consist of an inclined grate, terminating in an external charging shoot; it is necessary to carefully keep this filled with coal, which then descends by its own weight as the fuel in the furnace is consumed. From time to time the stoker stirs the coal with a fire-iron to prevent it from accumulating at the entrance of the grate.

The foundation works of the central station of the Avenue de Vendaine commenced some days ago. The Compagnie Edison intends to push forward the station very quickly, and it has commenced to lay its mains in order that they may be ready directly the station is in a condition to commence operations.

A competition between various alternate current arc lamps is about to commence at the Halles Centrales. Amongst the lamps taking part in it I may mention those of Siemens, Pilsen, Clerc, Potier, Dandeux, &c. The Dujardin accumulator, which has so far given very good results, is going to be manufactured on a commercial scale. The question of accumulators is attracting considerable attention in France just at present, and it is probable that before long we shall have some really good and durable accumulators.

AUSTRALASIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

SYDNEY, *April* 20, 1890.

The electric lighting industry has received an impetus in this Colony during the last week, the Newcastle Council having decided definitely to adopt this system of illumination. To compete successfully with gas in the very home of coal is highly encouraging, and there is no doubt it will influence the progress of electric lighting in other parts of the Colony. The successful tenderers for Newcastle are Messrs. Kirkland and Co., who are to supply and erect plant for 1,500 lamps. The boilers chosen are the Babcock and Wilcox, with Westinghouse compound engines and Westinghouse electrical system. Moss Vale was lighted by electricity for the first time some weeks back, Messrs. Wood Brothers being the contractors. It is only a small continuous-current plant; the plain two-wire system is used, and the street lamps are of 16 candle-power. Messrs. Wood, Brothers, are using a newly-patented reflector, which is said to give good results. This firm have also on hand the lighting of the youngest suburb of Sydney (Enfield), the streets of which they have contracted to light with 16 candle-power lamps for £5 per annum, permission being granted them to supply private customers. Goulburn, one of the largest towns in New South Wales, some time since decided to accept the tender of Messrs. Kirkland and Co., for a central station for their town; but added a proviso to their acceptance, that it was subject to their being able to borrow the money. Now they appear to desire to rescind their resolution, and to wait a while. If they should do so, it will only be one more to add to the string of municipal councils who have played with electric light contractors. The Borough Council of Redfern are again considering the adoption of electricity as an illuminant; and this time, apparently, they are determined to carry it through, and they will probably call for tenders shortly. Ashfield, another of the Sydney suburbs, is also considering the matter; and should these places really adopt it, Sydney itself will, indeed, be behind the times, as, so far, the City Council do not appear in a hurry to go into the matter, and there are far too many obstacles in the way of private enterprise here to make it possible in that way.

The electric light has during the past week been of considerable service at Bourke, in which place the dangerous aspect of the floods necessitated an embankment being formed round the town; the Government, with foresight, forwarded a number of Brockie-Pell arc lamps to the scene of action, which facilitated the nightwork considerably.

At Lambton, the work in connection with the new central station is progressing favourably, and the contractors, Messrs. Kingsbury and Co., hope shortly to have the plant working. This firm also obtained the contract for lighting the Hotel Australia, one of the largest buildings in Sydney, being for an installation of 1,000 lamps.

The electric tramway question is one which at the present time is causing a good deal of argument here, opinions being somewhat divided between the electric and the cable systems. A report was received from Sir J. Fowler on the subject, and the said report has been severely criticised by the Sydney daily press. The general impression appears to be that more reliable information could have been obtained; Sir J. Fowler, being a civil engineer only, cannot, according to one paper, be taken as an authority as an electrical or mechanical engineer. The evidence given by Mr. Cracknell, the Government electrician, and Mr. Kopsch, of the telegraph department, before the Board of Works, is all in favour of the Thomson-Houston overhead system; and the only fear seems to be the question of what gradient can be successfully negotiated on this system.

We have amongst us now a new firm of electrical contractors, viz., the Williamson Electric Company, who have made their headquarters in Sydney, having taken offices in Pitt-street.

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CORRESPONDENCE.

THE CROCKER-WHEELER ARC MOTOR SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to Mr. Firth's letter, which appeared in your issue of May 16th, respecting the above system. As my firm acts as European agents for the C. and W. system, and such a letter, if not replied to, may tend to create a wrong impression, I would say that Dr. S. S. Wheeler's complete specification was duly filed on May 7, 1889, in accordance with the International Patent Law, it being a complete specification previously deposited by him in the United States Patent Office as far back as June 9, 1888, which said patent, after careful examination by the Patent Office examiners, was accepted and issued in due course. Whereas, Messrs. Firth and Crabtree's final specification, as alluded to by Mr. Firth, was not filed until August 2nd following, and, in fact, not officially accepted by the Patent Office until November 2nd, or nearly six months after Dr. Wheeler's patent was granted, at which date, I may say, numbers of the C. and W. Motors were in full working order, including one exhibited by me at the late Birmingham Exhibition, and for which the silver medal diploma was awarded to the inventors. Therefore further comment from me on this point is unnecessary. It is easy to start a theory, but to start on entirely new lines and to make a practical and commercial success of a new invention is another thing altogether; but I can safely say that this has been successfully accomplished by Messrs. Crocker and Wheeler, and their associates, whose complete system for "electro-pulsion" I have no hesitation in saying is quite fundamental and unique, and the system is covered by about 30 patents taken out in various parts of the world, and covers large ground for many practical points of importance in connection with the electric traction industry. I therefore need say no more beyond apologising for taking up so much space in your valuable journal.—Yours, &c., ARTHUR SHIPPEY.

13 and 14, King-street, Cheapside, London, E.C.,
June 5, 1890.

PROTECTION FROM LIGHTNING IN RUSSIA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As everybody's thoughts are directed towards lightning and lightning conductors at the present time, I thought it might be interesting to note the effect of lightning in this part of the world, where all the buildings in the large towns are roofed with sheet iron, and the drain pipes terminate about a foot above the ground. Though thunderstorms are fairly frequent, it seldom or never happens that a house or other building in the town is struck, while in the country, where the cottages are covered with straw, it is an everyday occurrence. This seems to verify Prof. Oliver Lodge's theory.—Yours, &c.,

Moscow, May 16, 1890. LOUIS C. LOGAN.

THE LANE FOX PATENTS.

The following circular letter has been sent out to the trad by the Lane Fox Electrical Company:—

DEAR SIR,—1. As some misapprehension appears to exist in the mind of the public as to these patents, we wish to point out that they are at present held by the Lane Fox Electrical Company (Limited), subject to licences granted to the Brush Electrical Engineering Company (as successors of the Anglo-American Brush Electric Light Corporation), the Edison Swan United Company, and certain other persons abroad.

2. In the case of one patent, 3,988** of 1878, for distribution, Messrs. Crompton and Co., and the Swan United Company, have obtained an exemption from proceedings for infringement of the patents prior to December, 1882.

3. The Lane Fox Electrical Company (Limited) has been formed not merely, as has been alleged, to collect royalties; but to carry on a general electrical and incandescent lamp manufacturing business. If the Company is fairly met in the question of royalties but a small charge will be imposed, and it is anticipated that when the question is more fully understood, the reasonableness of the Company's charges will be appreciated by the industry.

4. It should be borne in mind that the Lane Fox patents are in no way invalidated by the long period during which they have been, or appear to have been, in suspense; nor, on the other hand, has that suspense been the fault of Mr. Lane Fox, or designed by him with a view of entrapping companies into their use.

5. At an early period the Lane Fox patents were disposed of by Mr. Lane Fox, to be worked with other patents, to the British Electric Light Company (Limited), and subsequently to the Anglo-American Brush Electric Light Corporation. Those who are conversant with the early history of electric lighting will know that until recently the principles of incandescent electric lighting were not generally understood; and though Mr. Lane Fox himself well knew the value of his patents, they were not properly appreciated by the companies who held them, and were mixed up and entangled with the claims of other patents held by the same companies for other and competing objects.

6. In illustration of the general contemporary ignorance of the principles now stated to be obvious, it may be mentioned that when first enunciated by Mr. Lane Fox they were received with ridicule and decried as impracticable, and that such staunch supporters of the system as Messrs. R. E. B. Crompton and W. H. Preece were at first opposed to them; even so great an authority as Sir William Thomson had for a time his doubts as to their theoretical soundness.

7. This opportunity may be taken to correct an impression which, to our great surprise, appears to prevail, namely, that Mr. Lane Fox confined himself some twelve years ago to shadowing forth the bare outlines of a scheme the essential details of which were laboriously worked out by others. This is not true. Not only were the principles of incandescent electric lighting distinctly enunciated by Mr. Lane Fox as stated above, but all details necessary to their efficient application were worked out by him independently, or through his agency, during the years 1878 to 1883. Thus in his hands the system became a thoroughly working system; installations were put up at home and abroad, and when Mr. Lane Fox temporarily abandoned electric work at the end of 1883, his system, which was ridiculed as late as 1881, was accepted and largely used.

8. After many abortive attempts to regain possession of the patents, attempts giving rise to "agreement" after "agreement" (each, as it was subsequently found, adding to, rather than removing the confusion), an agreement was finally come to upon the conclusion of the recent litigation between the Anglo-American Brush Electric Light Corporation and the Edison Swan United Company (Limited). By this agreement, dated December 3, 1889, each of the two litigating companies obtained a licence to use the patents in the future, and an indemnity in respect of the past; but, subject thereto and to certain licences affecting the foreign patents, all the patents were assigned absolutely to Mr. Lane Fox.

9. In February of this year the Lane Fox Electric Company (Limited) was formed to carry out the long-postponed designs of Mr. Lane Fox, and to vindicate his position as the inventor of the true principles of incandescent electric lighting. The Company, however, do not propose to charge vindictive royalties, or in any way to attempt to impede the progress already made, even by the unauthorised use of the Lane Fox patents.

10. Many times in the course of his prolonged negotiations with the Anglo-American Brush Electric Light Corporation Mr. Lane Fox was invited by competent financiers to join in the formation of a "ring" to control to their own exclusive advantage the electrical industry. Mr. Lane Fox declined. He wished to liberate and not to strangle the industry. Such still is his wish; and the wish of the Lane Fox Electrical Company is the same; but as true liberty consists in justice, and not in injustice, the Company will vindicate the patents, and insist upon the payment of royalties in respect of them.

11. In pursuance of this purpose the Company have formulated proposals, the terms of which will in due course be advertised; the pith of these proposals being that if those now using the patents will accept the proposed terms, or such modification of them as may be agreed upon by the middle of June next, no royalties will be claimed for the use of the patents prior to December 31, 1889.

12. It is confidently hoped that the companies and the electrical industry generally, will see the fairness and reasonableness of the terms proposed, and will co-operate in giving Mr. Lane Fox the position he can fairly claim in the electrical world.

(Signed) C. A. STEPHENSON,
Managing Director Lane Fox Electrical Company (Limited).

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THE "TRENT" GAS ENGINE.

Simplicity of arrangement and reduction in the number of working parts have been the objects chiefly aimed at by the makers of this engine, the "Trent" Gas Engine Company of Nottingham. Even running, which is so essential in dynamo driving, is ensured by the reception of an impulse at every revolution. The engine has only one cylinder, one piston, and a single crank, like that of a steam engine, made of the best forged steel, and without any complicated levers or links of any kind. It has no slide-valves, or small easily choked ports. All motions are positive, actuated me-

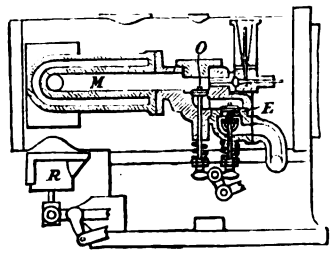

FIG. 1.—Elevation, showing the explosion chamber in section.

chanically and requiring no adjustment. As the gas is compressed to a relatively low pressure the engine is very easy to start. The explosion takes place outside the cylinder, in an explosion chamber, in which there is no working part. The most intense heat is, therefore, not on the piston, which consequently needs less lubrication

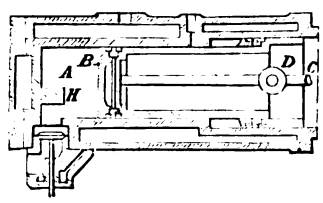

FIG. 2.—Vertical section of the engine.

and wears longer than is the case in other engines. The working parts consist of only the piston and three valves, all easily accessible and not subject to undue wear, and, excepting the exhaust valve, do not need any but the most occasional cleaning. The ignition, which is controlled by a small positive-acting valve, is re-

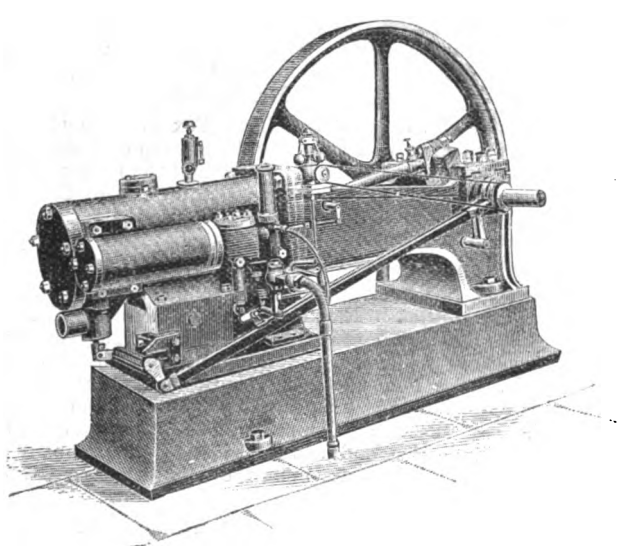

FIG. 3.—Perspective view of engine.

liable, and cannot take place prematurely. The exhaust gases escape at low pressure and therefore do not make any objectionable noise. We understand the Company are making 80-h.p. engines, having four impulses per revolution (quadruple-acting), especially for electric lighting purposes.

The following figures will help to explain the working of the engine :—A C is a cylinder of two diameters, in which works the double-headed piston B D. When the piston B D makes its out stroke, gas and air are drawn into the part C through a simple clack valve, E (Fig. 1). On the instroke of the piston B D, this valve is closed mechanically, and the mixture of gas and air contained in C is forced through the valve O (Fig. 1) into the explosion chamber M, where it is compressed (driving before it the exhaust gases remaining from the previous explosion, which escape through the valve R), and is then ignited. The resulting expansion impels the piston B D outwards. The acquired momentum of the fly-wheel performs the instroke.

Some recent tests of a four horse-power engine, by Mr. F. L. Guilford, gave a gas consumption per I.H.P. per hour of 17·6 cubic feet, and of 28·1 cubic feet per B.H.P. per hour ; and in engines of a later pattern these figures have been still further reduced.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—In our advertisement pages will be found particulars of the requirements of the Vestry of St. Pancras for works to supply electricity for a first installation of 10,000 16-candle power incandescent lamps, and for public lighting. There are seven contracts in all, which may be tendered for either wholly or in part, and in the event of any tender embracing more than one contract the amount of each must be separately stated. Drawings and specifications can be seen and full further particulars obtained at the offices of Prof. Robinson, 13, Victoria-street, London, S.W. The tenders have to be in before 4 o'clock on Monday, the 23rd inst., at the Vestry Hall, Pancras-road, London, N.W.

——— The Corporation of Swansea invite proposals from electric lighting companies for the execution and maintenance of all the works needed for the supply of electricity within the borough, in accordance with the Provisional Order obtained for the purpose by the Corporation. Copies of the conditions, Provisional Order, and lithographed plan can be obtained at the office of Mr. J. Thomas, Town Clerk, Guildhall, Swansea, on making a deposit of £5, which will be returned on receipt of a *bonâ fide* proposal. Proposals, endorsed "Electric Lighting," to be delivered to the Town Clerk by 30th inst.

——— The North-Eastern Railway Company invite tenders for the supply of (1) telegraph apparatus, and (2) telegraph wire and line stores during the six months ended December 31, delivered carriage paid at the Company's Telegraph Stores at York. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and tenders must be sent to the Secretary, at York, sealed and marked "Tender for Telegraph Stores," by noon on 9th inst.

——— Tenders are required by the City of Brussels from persons willing to tender for the supply of electricity to the whole of the city, for a period of 25 years. Specifications may be obtained from the Secretariat, Hôtel de Ville, Brussels, to whom tenders, endorsed "Soumission pour Distribution d'Électricité," must be sent by noon on August 1st.

——— Tenders are required by the Magistracy of Copenhagen for the supply and setting up of steam boilers, engines, dynamos, leads, and all the necessaries for an electrical installation of 14,000 (simultaneously burning) incandescent lamps of 16 candle-power, with wiring for 20,000. Conditions and drawings, price 12s. each, can be obtained from the Magistracy of Copenhagen, 4th Division, with translation into the German and English languages. Tenders are to be in by August 1st.

SALE BY AUCTION.—Mr. R. Thorowgood announces the sale by auction, at the Mart, Tokenhouse-yard, London, E.C., on Monday next, of some valuable freehold property known as Horns Mills, Hertford, fitted with modern appliances, and possessing 20-horse permanent water-power and 32-horse steam-power, with a siding on the G.N.R., together with outbuildings and offices, a modern-built residence, and several acres of meadow land. Further particulars are given in our advertising columns ; and full descriptive particulars and plans may be obtained of the Secretary at the Mart ; of Messrs. Bowlings, Foyer, and Horden, solicitors, 26, Essex-street, London, W.C. ; at the *Midland Counties Herald* office, Birmingham ; and of the auctioneer, High-street, Ware, Herts.

DISSOLUTION OF PARTNERSHIP.—It is announced that Messrs. W. Blenheim and P. Holland, trading under the name of Messrs. W. Blenheim and Co., manufacturers of electrical apparatus, at Egham, Surrey, have dissolved partnership.

REMOVAL NOTICES.—Messrs. Cuttriss and Co. inform us that they have removed from 72, New Briggate, Leeds, into much more extensive premises at Elmwood Electrical Works, Camp-road, Leeds. This removal has been necessitated by the greatly increased demand for Messrs. Cuttriss's motors and dynamos, and the increased room at their disposal at their new premises will enable them to manufacture machines for heavy as well as light work.

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REMOVAL NOTICES.—Mr. F. Geere Howard writes us that he has given up manufacturing, and intends devoting himself to contracting work only. He has removed from Cleveland Works to larger premises at 18, Berners-street, Oxford-street, London, W.

——— Messrs. S. A. Edwards and Co., importers of Swedish steel and iron, have removed from 6, Great Charles-street, to their newly-erected premises, 30, Easy-row, Broad-street, Birmingham.

A CARD INDEX TO CURRENT SCIENTIFIC LITERATURE.—The literature of applied science is scattered so widely amongst the British and Foreign technical and scientific periodicals, that it is well-nigh impossible for anyone to keep himself fully and *promptly* informed upon the most recent developments. With a view of assisting those who desire to keep abreast of the times the Newspaper Extract Agency, of 54, Charing Cross, has organised a special department on the reference card system.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

May 8, 1890.

7,186. W. P. THOMPSON. Liverpool. Improvements in welding metals electrically, and apparatus therefor.

7,196. H. GREFEN. London. An electric door lock.

7,209. L. SAUNDERSON. London. Improvements in electric arc lighting. (Date applied for under Patents Act, 1883, sec. 103, December 4, 1889, being date of application in United States.)

May 9, 1890.

7,219. J. PERRY. London. An electric supply motor.

7,225. T. J. BAKER. Stetchford, near Birmingham. Improvements in the construction of electric bell-pushes.

7,239. J. WOOLLEY and W. E. HUNNEX. Croydon. Improved switch for electric lighting.

May 12, 1890.

7,373. G. S. HOOKER. London. Improvements in electric switches.

7,378. A. BRÜLL. London. Improvements in electrical switches.

7,383. J. N. LEVSEN. London. An improved battery element.

May 13, 1890.

7,399. R. KENNEDY. Kilmarnock. Improvements in heating by magnetism and electricity.

7,422. F. BRYAN. London. Improvements in appliances used for protecting or regulating an electrical circuit.

7,425. M. S. CONLEY. London. Improvements in the method of producing alternating electric currents.

7,436. B. DUKES. London. Improvements in switches for electric currents (C. S. F. R. Bosse, Germany).

7,444. A. MILLION and P. BONY. London. Improvements in and relating to galvanic batteries.

7,456. A. DE BROUCHERE and L. ANSPACH. London. Apparatus for applying electricity to produce water-pressure for fire extinction or like purposes.

May 14, 1890.

7,473. W. B. SAYERS. Putney, Surrey. Improvements in electric incandescent lamps.

7,505. A. L. TAYLOR. Liverpool. New or improved safety devices for use with strong tensional electric currents for lessening fire risks.

7,511. M. IMMISCH. London. An improved brush for dynamos and motors.

SPECIFICATIONS PUBLISHED.

1839.

7,808. JULIAN. Electric alarm attachment. (Price 6d.)

7,894. ATKINSON. Distributing electricity (Price 8d.)

7,895. ATKINSON. Dynamos, &c. (Price 8d.)

9,258. RAWSON and RAWSON. Electric signal lamps. (Price 8d.)

10,695. LAKE (Hussey and another). Electric batteries. (Price 8d.)

10,696. LAKE (Hussey and another). Electric batteries. (Price 8d.)

11,070. JOHNSON (Riker). Secondary batteries. (Price 8d.)

11,179. SIEMENS BROTHERS and Co., Limited (Siemens and Halske). Electric meter. (Price 8d.)

11,191. BENSON. Electric lamps. (Price 6d.)

15,096. RATTRAY and LOWDON. Lampholder and switch. (Price 8d.)

20,660. WINCKLER. Electric signalling. (Price 6d.)

1890.

350. EISTEIN. Electric batteries. (Price 8d.)

5,067. LAKE (Barrett). Electric cables. (Price 8d.

5,344. LAKE (Garver). Electric currents. (Price 8d.)

5,423. WENSTROM. Electric currents. (Price 8d.)

Second Editions.

1881.

4,057. NEWTON (Société Universelle d'Électricité Tommasi). Continuous electric currents in railway carriages, &c. (Price 8d.)

1883.

5,741. SELLON. Secondary batteries. (Price 6d.)

Third Editions.

1881.

5,251. NEWTON (Volckmar). Secondary batteries. (Price 8d.)

1882.

2,818. SELLON. Secondary batteries. (Price 6d.)

COMPANIES' MEETINGS.

The Western Counties and South Wales Telephone Company (Limited).

The fifth annual ordinary general meeting of this Company was held on Monday, at the Grand Hotel, Bristol, under the presidency of Mr. Charles Nash.

The CHAIRMAN, in moving the adoption of the report, expressed regret at the absence of Messrs. J. S. Forbes and J. W. Batten (nominees of the National Company), in consequence of other engagements. It would be seen from the report that the capital expenditure to the end of 1889 was £139,593. 16s. 8d., and the gross revenue to the same date was £39,046. 19s. 6d. The whole of the preliminary expenses had now been cleared off, and not only had the plant been fully maintained and renewed, but it had in many cases been improved at considerable expense, by the substitution of the more efficient and durable copper and bronze wire for iron. The Directors felt some disappointment that the result of the year's work did not enable them to recommend a dividend on the ordinary shares; it was, however, proposed to add £500 to the special reserve fund, increasing it to £1,700. One principal cause of the small amount of net revenue was mentioned in the report, viz., the heavy necessary expenditure on trunk lines. The total expenditure on trunk lines up to the end of 1889 was, in round figures, £38,000, and this large outlay was only now beginning to be remunerative. It was gratifying to note that the use of the trunk system was increasingly popular amongst the Company's subscribers and the public. The increase in messages was not confined to Exchange subscribers and renters, but the outside public also largely used the call offices, the number of these latter calls having increased from 273 in December, 1887, to 1,772 in December, 1889, and to 1,968 in March, 1890. The total number of calls on the Company's trunk lines had been as given below, showing a monthly increase of 442 from September, 1887, to March, 1890:—

Total Calls on Trunks.

September, 1887	5,582
September, 1888	13,597
September, 1889	15,236
December, 1889	17,068
March, 1890	19,295

The calls last March were at the rate of more than 231,000 a year. Each call was answered, so that the number of communications had been at the rate of double these figures, or over 462,000. The cost of trunk lines to the end of 1886 was £11,009; 1887, £18,874; 1888, £29,823; 1889, £38,441; and the earnings of trunks per annum:—

December, 1886, at the rate of			£133
September, 1887	„	„	708
December, 1887	„	„	814
December, 1888	„	„	1,544
December, 1889	„	„	2,302
March, 1890	„	„	2,602

The increase of monthly earnings had been as follows:—September, 1887, to December, 1888 (16 months), £836 = per month £52 increase; January, 1889, to December, 1889 (12 months), £758 = per month £63 increase; January, 1890, to March, 1890 (3 months), £300 = per month £100 increase; thus the increase was progressive. Percentage of gross receipts on cost:— December, 1886, about 1¼ per cent.; December, 1887, 4¼ per cent.; December, 1888, 5¼ per cent.; December, 1889, 6 per cent. The large increase in calls during the current year gave confident promise of a further advance in this percentage. As yet the trunks had not been a direct source of profit, although the progressive increase in the monthly earnings, and the steady improvement in the percentage that the gross receipts bore to the cost, proved that they were no longer altogether unremunerative; but the indirect value of the trunk system in extending the Exchange business of the Company was very great. It was not merely in active business towns like Cardiff and Newport, where the calls amounted to several hundreds a day, that the value of the trunks was shown; but in quiet residential places like Bath, and in business places like Gloucester, where the value of the telephone to many of the subscribers was chiefly the power of communicating with Bristol, Cardiff, and other places; thus in many cases the trunk not only brought in its own revenue, but led to Exchange subscribers at each end. This experience made them anxious to extend trunks still further, as they were confident that many places which were at present quite unproductive would show a fair amount of business if connected

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with one or more of their leading centres. Worcester, for instance, had been a disappointing place. After three unsuccessful attempts to establish an Exchange, they had now no subscribers there, but were confident that it would help materially when connected with Birmingham in one direction and with Gloucester and Bristol in the other. As many as sixty firms had promised to subscribe when the connecting; trunk was made and as arrangements were now complete for the connection with Birmingham, it might be hoped that in a month or two Worcester would yield a fair profit. They had lately opened an Exchange at Weston-super-Mare, and had already a fair number of subscribers, but they would not have obtained them without the promise of immediate trunk connection with Bristol. On completion of that line, which was now in a forward state, they looked for a large increase in the business at Weston-super-Mare. It was also important to complete the interval between Newton Abbot and Weston, bringing Exeter, Plymouth, and Torquay into direct communication with them. The effect of this would doubtless be to still further increase the Weston business, and that of Exeter and other places; and it would give the opportunity of opening Exchanges at Bridgewater, Taunton, and possibly at Wellington, Dawlish, and Teignmouth, with a fair prospect of business. Shrewsbury was another place where a trunk connection was much wanted. Salisbury was at present quite isolated; but by the construction of a trunk line from Bath, *viâ* Bradford, Trowbridge, Westbury, and Warminster, and continued to Winchester, these places would be put into direct communication with Bournemouth, Southampton, and Portsmouth, and with the whole of the Bristol and South Wales districts, and a fair amount of business would doubtless result. Without this trunk connection they had hitherto found it hopeless to establish an Exchange at Salisbury. With it they might expect fair business there, and probably at Trowbridge and other towns. A further extension of the trunk line from Winchester to the boundary of this Company's district near Reading, when met there as arranged for by the National Company, would place the whole of the principal towns in this district, as well as Bournemouth, Portsmouth, and Southampton, in communication with London, the effect of which could not fail to be very considerable. Another cause of the small net balance was that the auditors had adopted a different plan in dealing with some items of expenditure, charging a larger proportion to revenue than before. This was too technical a matter for explanation there, but it must be evident to every business man that, in an undertaking like theirs, with some parts of the system fully developed, others partially so, and others, again, only in an incipient state, it was only reasonable to expect a difference of opinion as to what portion of the expenditure was fairly chargeable to capital, and what applied to revenue. Another cause of the smallness of the balance was that during the year 1889 the progress of their Exchange and private line business was less rapid than in 1888. The increase in ordinary receipts in 1888 was £99 per week, and that for 1889 £74 per week, making a difference of about £1,300 in the year. It was not easy to account for this, but it was certainly not to be taken as a sign that the use of the telephone had nearly reached its limit, for during the present year the advance at several of their large centres had been very rapid. For instance, Bristol had increased at the rate of £11 a week, against £7 a week last year, and Cardiff at the rate of £18 a week, against £13 last year. During the first twenty weeks of this year, as compared with the same period last year, the increased receipts from all their Exchanges and private lines had averaged £90 per week, and during the last five weeks as much as £104 per week, so that, without venturing to look into the future, they could state as a fact that the Exchange and private line business of the first five months of the current year showed a decided improvement on 1889, in addition to the excess of income on trunks already referred to. On the whole, with the improved state of general business, and the adoption of the telephone in all parts of the world, and in many to a much greater extent—as in America, where there were stated to be 300,000 telephones at work—he could not doubt that its use would be greatly extended in this country. There was certainly no reason to be discouraged, for the telephone was now a necessity at their public offices, to police and fire brigades, wholesale and retail merchants, so that as fresh towns were connected by trunk lines there would doubtless be a great extension in its development. But the usefulness of the telephone was not limited to these classes, as was proved by their own experience:—Thus, at Portsmouth they had 16 hotels connected, at Torquay 11, and at Bournemouth, including boarding-houses, 27; in Bristol and Clifton they had 2—the Grand and the Clifton-down Hotels. Why was this? Again, at Bournemouth they had 20 doctors on the Exchange, and at Plymouth (the three towns) there were 20; in Bristol *nil*, and 3 in Clifton. Private residents were another large class that had only partially availed themselves of the telephone. In proportion to population Torquay took the lead with 35, Bournemouth had 24, and Plymouth 38. At most of their other Exchanges there were very few private resident subscribers. These figures showed that there were large classes that had as yet failed to realise the advantages of the telephone; and he did not doubt that, if more of their large retail businesses were connected, many more private residents would find it to their advantage to subscribe. There was still much ground unworked. For instance, Falmouth and Truro were now asking for an Exchange, and many other towns might by degrees desire not to be left out of a system which was spreading over the country.

Mr. H. FEDDEN seconded the resolution.

Colonel SAVILE supported the resolution. For so young a Company he felt the dividend they had earned was satisfactory. The business seemed to be growing and increasing in a way they could scarcely have expected. He did not see any charge for the Directors' fees in the balance sheet for the past year. They ought not to expect them to work for nothing, and at a later stage of the meeting he should move that the sum of £500 be paid to the Directors by way of remuneration.

The SECRETARY explained that they could not insert that sum in the balance sheet without the sanction of that meeting.

The Report was then adopted.

The CHAIRMAN then moved—

"*That a dividend of 6 per cent. per annum upon the amounts paid up on Preference shares to the 31st of December, 1889, be declared, and that the amounts already paid by the Directors on account of such dividend, being the whole amount, be approved and confirmed.*"

Mr. R. CORY seconded the motion, and it was carried.

Mr. READ proposed the re-election of Mr. Thos. Pole, one of the retiring Directors; and the proposition was seconded by Mr. W. WHITE, and adopted.

Mr. READ moved, and Mr. WHITE seconded, the re-election of Mr. Henry Fedden, the other Director who retired. This motion was carried.

The CHAIRMAN proposed the re-election of the auditors, Messrs. Hudson, Smith, Briggs, and Co.

Mr. R. CORY seconded the resolution, which was adopted.

The CHAIRMAN moved that the sum of £500 be added to the reserve fund, making a sum total of £1,700.

Mr. M. WHITWILL seconded the resolution, which was adopted.

The remuneration of the auditors for the year 1889 was fixed at 95 guineas, this proposition being submitted by the CHAIRMAN and seconded by Mr. READ.

Col. SAVILE moved, and Mr. W. WHITE seconded,

"*That the remuneration of the Directors be fixed at the sum of £500 for the year 1889.*"

The motion was unanimously agreed to.

The meeting was then made an extraordinary one, for the purpose of making verbal alterations in the Articles of Association caused by the National Telephone Company (Limited) taking the place of the late United Company in certain contingencies.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN

PHOSPHOR BRONZE.

PHOSPHOR BRONZE

BEARINGS, BUSHES,

AND OTHER PARTS OF

ELECTRICAL MACHINERY.

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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These alterations were proposed by the CHAIRMAN and seconded by Mr. CORY, and were agreed to, and the confirmatory meeting was fixed for that day four weeks.

Mr. FEDDEN proposed a vote of thanks to the Chairman ; and this was unanimously passed.

The CHAIRMAN, in acknowledging the resolution, said he did take a great interest in the Company ; but he must not omit to say that Mr. Lewis, their energetic manager, was the mainstay of the concern, and they must thank him for his continued exertions on the Company's behalf.

NEW COMPANIES REGISTERED.

BISHOP'S STORTFORD ELECTRIC LIGHT AND STEAM LAUNDRY COMPANY (LIMITED).—This Company was registered on the 28th ult., with a capital of £10,000, in £1 shares, to carry on at Bishop's Stortford, or elsewhere, the business of electric lighting, and also of a steam laundry. Registered without special articles. Solicitors: Messrs. Acklands and Nockolds, Bishop's Stortford.

"THE ENGINEER" COMPANY (LIMITED).—This Company was registered on the 24th ult., with a capital of £160,000, in £100 shares, to purchase the *Engineer* newspaper. The subscribers are :—C. A. Close, Harrow, solicitor ; V. Pendred, C.E., 19, Pendennis-road, Streatham ; D. L. Holmes, 16, Cornwall-gardens, barrister ; J. J. Stansfield, B.A., 41, Ladbroke-square ; S. White, Babington-road, Streatham, publisher ; J. A. Edwards, 164, Brompton-road, accountant ; W. R. von Glehn, 22, Campden-hill-gardens, merchant. The number of Directors is not to be less than 3, nor more than 5 ; the subscribers are to appoint the first. Qualification, 30 shares. Solicitors : Messrs. Close and Co., 23, Great Marlborough-street.

RATCLIFFE AND HORNER (LIMITED).—This Company has been registered with a capital of £20,000, in £10 shares, to carry on a business as mechanical engineers, machine and engineering tool makers, boiler makers, safe manufacturers, iron founders, &c.

CITY NOTES, &c.

THE ALUMINIUM INDUSTRIE GESELLSCHAFT OF NEUHAUSEN.—From the *Electrotechnischer Anzeiger* we learn that the Aluminium Industrie Gesellschaft of Neuhausen has paid a dividend of 4 per cent. on its capital, besides writing off 177,356 francs as a sinking fund for the patents in its possession, the latter now only standing at 34,228 francs in the Company's books.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The Directors of this Company have declared an interim dividend of 3s. per share, free of income-tax, being at the rate of 6 per cent. per annum, for the quarter ended March 31st last, and payable on the 24th inst. The books of the Company will be closed from the 17th to the 23rd inst., both days inclusive.—The receipts for the week ended May 30th amounted to £4,171.

COMMERCIAL CABLE COMPANY.—This Company has declared a quarterly dividend of 1½ per cent., payable July 1st. The transfer books will be closed from the 20th inst. until July 2.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of May were £3,400, as compared with £3,513 in the corresponding month of last year. The receipts for the month of February, estimated at £3,300, realised £3,391.

DICK, KERR, AND CO. (LIMITED).—The prospectus has this week been issued of Dick, Kerr, and Co. (Limited), with a capital of £160,000, in 32,000 shares of £5 each, made up of 16,000 Seven per Cent. Cumulative Preference shares and 16,000 ordinary shares. The prospectus provides that not less than one-fourth of the surplus profits shall be placed to a reserve fund until such fund amounts to £61,500. Out of the balance of profits the ordinary shares are to receive 7 per cent., and the surplus, after deducting 10 per cent. additional remuneration for the Directors, is to be divided equally between both classes of capital. The present issue is made under the auspices of the Trustees, Executors, and Securities Insurance Corporation (Limited), and is for the Preference shares only at par, payable—10s. per share on application, £1 on allotment, £1. 10s. on June 25th, and £2 on July 31st. The Directors include Major-General C. E. Webber, C.B. The Company is established to acquire and develop the engineering and contracting business carried on by Messrs. Dick, Kerr, and Co. at Kilmarnock and London. As our readers are aware, the firm has an acknowledged reputation for the supply and manufacture of tramway permanent way material, portable railway and rolling stock, railway permanent way material, cable tramway machinery, cable tramways, gas engines, &c. The Secretary of the Company is Mr. G. W. Carr, and the offices are at Leadenhall House, London, E.C. The lists of application closed yesterday (Thursday).

DIRECT SPANISH TELEGRAPH COMPANY.—The receipts of this Company for the month of May amounted to £2,244, as compared with £2,040 for the corresponding period of 1889, showing an increase of £204.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of May amounted to £53,373, as against £52,704 for the corresponding period of 1889, or an increase of £669.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of May were £41,230, as against £41,064 in the corresponding period, showing an increase of £166.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows :—Receipts in May, 1890, £24,000 ; January 1 to May 31, 1890, £105,800. Corresponding months in 1889, £106,800 ; ditto in 1888, £108,400.

GREENWOOD & BATLEY (LIMITED).—The second annual ordinary general meeting of Greenwood and Batley (Ltd.) was held on Thursday at the offices, 16, Great George-street, Westminster, under the presidency of Mr. Arthur Greenwood, who stated that the result of the first year's operations of the Company had been fairly satisfactory, whilst there was every prospect of the present year being a good one. A motion for the adoption of the report and the statement of accounts, and the declaration of a dividend at the rate of 7 per cent. per annum on the Preference shares and 10 per cent. per annum on the ordinary shares, was unanimously agreed to ; and the meeting having been made extraordinary, it was resolved, on the motion of the Chairman, to make a further issue of the capital of the Company to the extent of £44,000, viz., £16,000 in Seven per Cent. Cumulative Preference shares and £28,000 in ordinary shares, to be offered (as the report stated) in the first instance *pro ratâ* to the shareholders at moderate premiums.

NORWICH ELECTRICITY COMPANY (LIMITED).—The first general meeting of this Company was held recently under the presidency of the Chairman, Mr. F. W. Harmer, who said that as the requisite Parliamentary authority to supply electricity upon a large scale in Norwich cannot be obtained until next year, the Directors would take advantage of the delay by profiting by the experience of other towns in the erection of central station works, and by obtaining the latest improvements in electric plant.

PHŒNIX ELECTRIC LIGHT AND POWER COMPANY.—From the liquidator's report, to be put before the shareholders on the 30th inst., it appears that the money received, including £125 from the vendor, "in settlement of claim for return of purchase-money," amounts to £1,617. 4s. 10d. Out of a total list of debts and claims sent in, amounting to £25,105. 17s., £659. 13s. 1d. were admitted, and these have received 3s. 9d. in the pound. This absorbs £123, which is the total available for distribution out of the £1,617. 4s. 10d. obtained by liquidator's hands.

STOCK EXCHANGE.—Application has been made to the Committee to appoint a special settling day in the ordinary shares of the Notting Hill Electric Lighting Company (Limited).

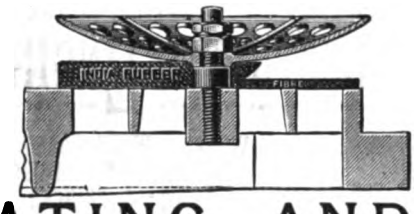
WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended 30th May, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,262.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month ended 31st May amounted to £6,075.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended May 31st show an increase of £131, as compared with the corresponding period.

WESTERN UNION TELEGRAPH COMPANY (LIMITED).—This Company has acquired the telegraph lines of the San Antonio and Aransas Pass for $100,000. The Company has also secured control of the Roy State Railway Telegraph Company for 99 years.

NEW VALVE



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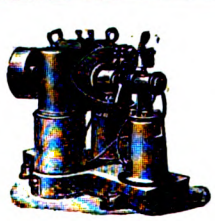
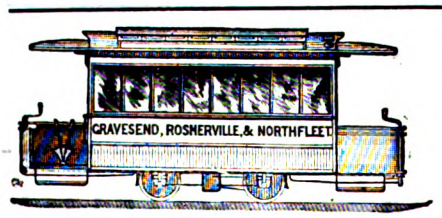
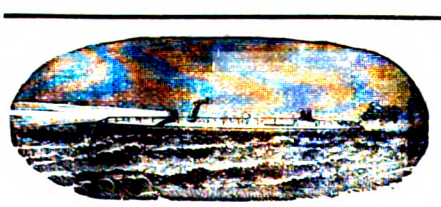
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, May 28.	Price Wednesday, June 4.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 4. Highest.	Lowest.
£			**TELEGRAPHS.**			£ s. d.			
1,381,330	Stock	12/6	Anglo-American	50 51	50 51	5 7 10	Jan., Apr., July, Oct	50	..
2,809,310	Stock	25/0	Do. Preferred	86 87	86½ 87½	6 5 9	" "	87½	87
2,809,310	Stock	..	Do. Deferred	15½ 16½	15½ 16	..	February	15½	..
25 ,000	£100	4%	African Direct, 4 per Cent. Debentures	98 101	98 101	3 19 3	January and July	100½	100
130,000	10	3/0	Brazilian Submarine	11⅜ 12⅛	11⅜ 12⅛	6 2 5	Mar., June, Oct., Dec.	12⅛	11⅛
69,200	100	5%	Do. 5 per Cent. Bonds	101 103	101 103	4 17 1	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	106 109	106 109	4 11 9	June and December	..	..
16,000	10	0/0	Cuba Submarine	11 11½	11⅜ 12⅛	7 6 11	February and August	12⅛	12
6,000	10	10%	Do. Preference 10%	17½ 18½	17½ 18½	5 8 1	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3⅜ 4⅛	3⅜ 4⅛	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10⅛ 10⅜	10⅛ 10⅜	6 14 11	Jan., Apr., July, Oct	10⅜	10⅛
400,000	10	2/6	Eastern	13⅞ 14	13⅞ 14⅛	4 11 3	" "	14⅛	13⅞
70,000	10	6%	Do. 6 per Cent. Preference	14¼ 15½	14¼ 15½	3 18 8	" "	15½	14¼
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107 110	107 110	3 12 9	May and November	..	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	13½ 14	13⅜ 14⅛	4 18 3	Jan., Apr., July, Oct.	14⅛	13⅜
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101 103	101 103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 per Cent. (Austin. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	" "	103	..
180,227	10	2/0	Globe Telegraph and Trust	8⅜ 8⅞	8⅜ 9⅛	5 9 7	Jan., Apr., July, Oct.	..	..
180,042	10	6%	Do. 6 per Cent. Preference	14⅜ 15⅛	14⅜ 15⅛	3 19 4	" "	..	..
150,000	10	5/0	Great Northern	15⅜ 16⅛	15⅜ 16⅛	4 12 4	Jan., July, and April	16	15⅞
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102 105	102 105	4 15 3	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	38 40	38 40	6 5 0	April and October	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 15 9	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅛ 8	7⅛ 8	5 0 0	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	110 115	110 115	5 4 4	" "	..	..
15,609	£10	3/6	West African	9 10	9 10	..	.. ..	9⅛	..
290,000	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	101⅛	99½
30,000	10	2/0	West Coast of America	5½ 6⅛	5½ 6	10 0 0	January and July	6⅛	5⅞
150,000	100	8%	Do. Debentures 8%	115 120	111 116	6 17 11	June and December	116⅛	112
88,321	10	Nil.	West India and Panama	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅞	..
34,563	10	6/0	Do. 1st Preference 6%	11 11½	11 11½	5 4 4	April and October	11½	11
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12½ 13½	12½ 13½	..	..	..	..
64,572	15	6/0	Western and Brazilian	9⅞ 10⅛	9⅞ 10⅛	6 10 1	May and November	10⅛	10
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½ 6⅞	6½ 6⅞	..	..	6⅞	6½
26,986	7½	4/6	Do. 5 per Cent. Deferred	3⅝ 4	3⅝ 4	..	..	..	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106 109	106 109	5 10 1	..	106⅜	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104 107	104 107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99 101	99 101	5 18 10	March & September	..	..
			TELEPHONES.						
224,350	14/0	0/5½	Consolidated Telephone Const. and Mainten....xd	⅛ ⅜	⅛ ⅜	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼ ⅜	¼ ⅜	4 8 3	Yearly	..	..
386,875	5	3/0	National	5½ 6⅛	5½ 6	..	June and December	6	5⅝
49,825	5	1/4½	Do. New	5½ 6	5½ 6	..	..	5⅞	5½
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference	12½ 12⅝	12⅛ 12⅝	4 14 1	June and December	12⅛	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference	10⅛ 10⅜	10⅛ 10⅜	..	" "	..	..
209,750	1	..	South of England, Ordinary	⅛ ..	⅛ ..	..	.. ..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3⅛ 3⅜	3⅛ 3⅜	..	.. ..	..	..
55,000	5	2/0	United River Plate	4⅛ 5	4⅛ 5	..	January and July	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	.. ..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	.. ..	.. ..	..	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	2⅛ 3	2⅛ 3	..	.. ..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5 5⅛	5⅛ 5⅜	..	.. ..	..	..
42,853	5	..	Westminster Electric Supply	1⅞ 2⅛	1⅞ 2⅛	..	.. ..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅝	..
63,416	2	1/2	Do. Preference	1⅝ 2	1⅝ 2	6 0 0	..	..	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5⅛ 5⅜	5⅛ 5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction	.. ..	9⅞ 10⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	4⅜ 5⅛	4⅜ 5⅛	..	..	4⅛	4⅞
20,000	5	..	Fowler-Waring Cables	2⅛ 2⅜	2⅛ 2⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19 20	19⅜ 20⅛	4 17 7	February & August	19⅝	19⅜
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	.. ..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5⅛ 5⅜	5⅛ 5⅜	3 13 0	..	5⅛	..
37,350	12	36/0	Telegraph Construction and Maintenance	44 46	44 46	5 3 11	March and July	44⅞	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	..	..	..







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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 630.—Vol. XXV. FRIDAY, JUNE 13, 1890. Price Fourpence.

NOTES.

Whatever may be thought of the Pacific cable scheme, of which Mr. Harold Finch Hatton is the exponent, his appearance as a competitor of Mr. Henniker Heaton for the distinction of having reduced the cable rates to Australasia is a welcome relief to the monotony of the last-named gentleman's pertinacity. It will be pleasant pastime to see the two rival claimants fight it out between themselves. Meanwhile, to all sensible people it must be evident that neither of these self-constituted instruments of intimidation has exerted the least practical influence on the action of the Eastern Telegraph Cable Companies, the simple fact being that propositions which the Companies long ago voluntarily put forward have now at length been accepted substantially by the Governments concerned. The rates will probably be reduced in consequence, by way of experiment; and Mr. Henniker Heaton's share in the business appears to amount to this, that he somehow or other got to know that the Australasian Agents-General were about to consent to the Companies' propositions, and was able to telegraph to Australia to that effect a day or two before the decision was made publicly known.

The opposition which was offered to the third reading of the Central London Railway Bill on Friday evening last was not of a very effective character, either as regards the arguments brought forward or the results obtained. It is satisfactory to find that this attempt to delay a great and necessary public improvement met with scant support in the House of Commons; and it is to be hoped that the Bill will be allowed to pass through its remaining stages without further opposition. It is proverbially rash to prophesy; but it does not require much hardihood to predict that the West End shopkeepers—to whom this persistent opposition is mainly due—will benefit as much as any section of the community by the general introduction of electric traction.

A description of the new Westinghouse arc-light system was given in our issue of the 25th April; and we are now able to publish a more detailed account of the method of constant-current regulation adopted in this alternating system. Transformers regulating for constant potential are so exclusively used that the properties of those regulating for constant current seem at first surprising. Thus, short-circuiting the secondary of a converter appears a startling method of putting it out of circuit; yet, by so doing, the potential absorbed is reduced to a minimum, and the energy wasted is very small. The series of transformers in circuit with the alternator must be regarded as a non-inductive resistance, owing to the effect of secondary currents, which, since the converters are short-circuited when not in use, are always able to practically neutralise the magnetising effect of the primary current. The lag of the current behind the E.M.F., caused by the very high self-induction of the armature, is diminished as the load is increased, owing to the increased ratio of the resistance to the self-induction; and by arranging that as the lag diminishes the neutralising effect of the armature current on the field is rendered less important, the E.M.F. of the machine is made to increase in proportion to the load. The system is peculiarly adapted for arc lighting, owing to the rapid rise of potential if the current diminishes. The use of resistance coils in series with the lamps, which are necessary on constant-potential circuits, is thus avoided. The method of regulation appears to be very successful, and the possibility of completely separating the lamp circuits from the high-potential mains is a great advantage. It is, indeed, a curious commentary on the generally accepted belief that the use of alternate currents necessitates greatly increased safeguards against danger to life, that the Westinghouse Company should now be introducing a system for series arc-lighting, in which, by the use of alternating currents, an immunity from danger is secured impossible of attainment in continuous-current high-tension systems.

This self-regulating alternate-current generator brings to mind the machine described by Mr. Mordey in his Paper on "Alternate-Current Working." It will be remembered that during the discussion Prof. Forbes, who had been independently at work on a similar machine, stated that "the self-induction of the machine in the form in which it was made was enormous, and the variations in volts when the different strengths of current were taken off were something perfectly surprising—in fact, you might almost say that the current was constant."

From a map of the North of England district of the National Telephone Company which lies before us, the National Company appears to have covered this busy part of the United Kingdom with a very complete network of trunk wires. Taking Manchester as the centre of the system, the lines branch out in all directions, to Liverpool, Leeds, Bolton, Brad-

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ford, and Blackburn; and southwards to Sheffield and Nottingham; and we trust that before many more months have elapsed we shall witness the completion of that long-promised trunk wire to the north, placing the metropolis in direct telephonic communication with the great industrial towns of Lancashire and Yorkshire. The Western Counties and South Wales Telephone Company is also actively extending its trunk system; and at the recent general meeting of this Company the Chairman expressed a hope that London would soon be in connection with the principal towns of the south and west. Although the greater part of the district served by the Western Counties Company can scarcely be termed a valuable one from the inter-urban telephonic point of view, yet the direct return upon that Company's large outlay on trunk lines is very encouraging. If the receipts from inter-urban messages continue to increase at their present rate, these trunk lines will confound the prophets by proving themselves self-supporting, though doubtless their indirect value will always remain their true *raison d'être*. When these ambitious projects are fully realised, a thorough overhauling of the metropolitan system should be the next item on the programme.

At the meeting of the Physical Society on Friday last Mr. H. Tomlinson drew attention to a remarkable influence of temperature on the Villari critical point of iron. It appears that at ordinary temperatures there are, for a given magnetising force, two values of the load at which a Villari critical point occurs, and that as the temperature rises these values approach each other until at high temperatures no critical point exists. As with the other effects of temperature on magnetisation no explanation appears at present possible; but the very definite results of this investigation may hereafter be of value in testing new theories.

At the same meeting Prof. Rücker read an important Paper by two of his students, Messrs. Robson and S. W. Smith. The subject treated was the diurnal variation of the magnet at Kew, and the result of the work will probably have great influence in deciding the manner in which the mean value of the diurnal variation is calculated in magnetic observatories both at home and abroad. The work of the authors, taken in conjunction with that of previous investigators, conclusively shows that the mean value calculated from observations taken on five selected days of the month, differs only slightly, and in a determinate manner, from the mean value calculated from practically all the observations taken during the month. The great expense necessary for the complete calculations is thus to a large extent avoided; and as most observatories can afford the expense of the simpler method, while only a few, such as the one at Greenwich, are competent to carry out the complete calculation, the result will be that a much greater collection of statistics will be annually added to the data from whose study we may hope in future to learn the explanation of terrestrial magnetism. This is more especially the case as there seems reasonable ground for hope that the various observatories may be induced to perform the calculations on a common plan.

An Electric Organ.—The fine organ of Nôtre Dame has just been fitted with electro-pneumatic appliances.

The Imperial Academy of Sciences.—Lord Rayleigh has been elected a corresponding member of the Imperial Academy of Sciences, Vienna.

Personal.—Mr. Albion T. Snell, M.I.E.E., M.I.C.E., has been appointed works manager and chief engineer to the General Electric Power and Traction Company (Limited).

The North Metropolitan Tramways Bill.—The Unopposed Bill Committee of the House of Lords passed this Bill on Friday last. The Bill has now received the sanction of both Houses.

Gas and Electricity.—At the meeting of the Gas Institute next week at Ryde, a Paper by Mr. A. F. Guy, entitled "Shall Gas Undertakings supply Electricity? Yes," is down for reading.

Manchester.—The compulsory area of supply adopted by the Gas Committee of the Corporation for inclusion in the Provisional Order for the electric lighting of the city is about 393 acres in extent.

Honours.—The President of the Republic of France has, by request of the Académie des Sciences, conferred on Prof. Sylvester and Prof. Cayley the "decoration" of an officer of the Legion of Honour.

The Central London Railway Bill.—The Queen's consent on behalf of the Crown to the Central London Railway Bill was signified and the Bill read a third time in the House of Commons last Wednesday night.

A Central Station Struck by Lightning.—The Manhattan Electric Lighting Company's station in Eightieth street, New York, was set on fire by lightning on Tuesday last. The loss, it is estimated, will amount to $60,000 (£12,000).

Strike at Messrs. Ganz and Co.'s Works.—The *Elektrotechnischer Anzeiger* states that a strike has broken out at Messrs. Ganz and Co.'s, originating, it is said, with the foreign workmen. An advance was asked for but not conceded.

Royal Society.—Among the Papers down for reading yesterday at the Royal Society was one by Dr. Beevor and Prof. Horsley, F.R.S., "A Record of the Results obtained by Electrical Excitation of the so-called Motor Cortex and Internal Capsule in an Ourang Outang (*Simia satyrus*)."

Stockton.—With regard to the Provisional Order just issued to the Corporation, the charge proposed to be made is 13s. 4d. for any amount up to 20 units, and for each unit over 20 units 8d. It has been decided to apply to the Local Government Board for sanction to borrow £25,000 for electric lighting.

Electric Launches at Edinburgh.—The result of the first week's running of the electric launches on the Union Canal to and from the Edinburgh Exhibition has proved highly satisfactory. Some days only two boats were on the service, and the weather was unfavourable, but the receipts amounted to £100, and 6,500 passengers were carried.

Institution of Civil Engineers.—The name of Mr. C. H. Wordingham should be added to the list (*The Electrician*, June 6, p. 109) of those who obtained awards for communications submitted during the past session of this institution. Mr. Wordingham obtained a Miller Prize for his Paper on "Telephonic Switching," read at a Supplemental Students' Meeting.

Electric Traction in Liverpool.—Having obtained permission from the Health Committee of the Corporation, an accumulator car left the Walton depôt of the Liverpool Tramway Company early on Monday morning and made the round trip to the pierhead. The experiment was made under the guidance of the Electric Traction Company's engineer, Mr. Thomas Frazer.

Welding by Electricity.—Some electric welding experiments were shown on Tuesday at the works of Messrs. Clarke, Chapman and Company, Gateshead, to an interested company. The operations were conducted under the supervision of Mr. F. C. Fish, electrical engineer for the Welding Company, and Mr. Boland, representative of the American proprietors of the patent.

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The Mariotti Multipolar Dynamo.—The Société des Téléphones de Zürich have just brought out a dynamo designed by their chief engineer, M. Mariotti. The machine is of the multipolar type, with a ring armature embraced alternately by external and internal pole-pieces. Some tests with a 20 horse-power dynamo of this type are said to have yielded very satisfactory results.

Ipswich.—At a recent meeting of the Ipswich Paving and Lighting Committee, a communication was read from the Brush Electrical Engineering Company notifying that, in consequence of a technical irregularity in the form of notice given, the Board of Trade had decided not to deal with their application for an Order this year. Therefore the Company would not be able to take steps to provide electric light for the present; but intended to renew the application in proper form for next Session.

Foreign Contracts.—In a Parliamentary paper just published, a return is given of all contracts for articles of home manufacture between April 1, 1889, and March 31, 1890, with contractors outside the Kingdom. The contracts thus entered into by the Admiralty were for carbons for electric light, £228; Mangin mirrors for electric light projectors, £11,236—total, £11,464. The only other department which entered into such contracts was the Post Office, which in this manner spent £1,016 on Hughes' telegraph instruments.

The Lane-Fox Patents.—In a circular letter which the Lane-Fox Electrical Company is sending out to all "undertakers" using the Lane-Fox system of distribution, the royalties demanded are 50 per cent. less than those which it was originally intended to enforce (*Electrician*, May 30th). The amounts are now: (1) ½d. per Board of Trade unit supplied; (2) ⅛d. per Board of Trade unit supplied, such payment to continue after the expiration of the patent for such a term as would render it equivalent to No. 1. In respect of private installations, a circular will shortly be issued proposing a payment of 3s. 6d. per annum per 16 candle-power lamp.

Overhead Wires.—In the House of Commons on Monday night Mr. Dixon-Hartland asked the Attorney-General whether the new electric-light companies in London were legally empowered to disfigure the streets and greatly increase the risk of fires by putting their wires overhead instead of underground. —The Attorney-General replied that under the Electric Lighting Acts of 1882 and 1888 powers are reserved to the County Council and to the Board of Trade for regulating and controlling the cases in which overhead wires may be used, and, in his opinion, these powers were sufficient. The information before him did not tend to show that overhead wires increased the risk of fires.

The International Telegraph Conference.—We are informed that notification has been given by Mr. Fuller and Major Wood, the respective representatives of the Brazilian Telegraph Cable Companies, that a reduction of 50 per cent. will be given from the 1st July next for Press messages (subject to the usual regulations governing the transmission of this class of correspondence) to and from the East Coast of South America.—It is expected that the Conference will conclude its labours on the 18th or 19th inst. The Telegraph Companies entertain the French Minister of Commerce, of Industry, and of the Colonies, and all the Delegates to the International Telegraph Conference, at breakfast, on Tuesday, the 17th inst., at the Hotel Continental, Paris.

St. Austell.—The low-tension station which was opened at St. Austell in 1887 by Mr. J. E. Veale now supplies between 50 and 60 shops, hotels and private houses. Several high candle-power incandescents are employed, and at the Congregational chapel a small electric motor is used for blowing the organ. As a striking illustration of the advantages of electricity as a motive power, it may be mentioned that a St. Austell tradesman, whose premises were lighted by electricity, recently received an urgent order for the making of a large tent cover. A small electric motor was hired from Mr. Veale's works, and the machine was worked by this motor. By this means an order was executed which could not otherwise have possibly been completed in time.

St. Martin's Vestry v. Gordon.—In the Court of Queen's Bench on Saturday a matter was decided, by the Lord Chief Justice and Mr. Justice Wills, of some importance to those using electricity for lighting and other purposes. The St. Martin's Vestry, who were the appellants, appealed against a decision of the police magistrate at Bow-street. The point at issue was whether the clinkers from the furnaces in the basement of an hotel, of which Mr. Frederick Gordon was the proprietor, was trade refuse, for the removal of which payment might be demanded. The boilers were used to generate steam for electrical purposes. Their lordships held that the clinkers were not trade refuse, and dismissed the appeal, giving leave, however, to the appellants to further appeal if they were desirous of so doing.

An Electric Call System for Boy Messengers.—The Boy Messenger Company, which has now been in successful operation for about three years, is about to organise a system of electric calls, to enable customers to signal from their own office or private residence for a messenger; and they are seeking to obtain a licence from the Postmaster-General for such a system of electric signals as would meet their needs. With a view of obtaining an expression on the part of the public in favour of the system in order to satisfy the Postmaster-General of the extent of the demand for it, a memorial is being extensively signed by all sections of the London public. The petition can be signed at any of the following places, viz:—Star-yard, Carey-street; 139, Oxford-street; 9, Bridge-street, Westminster; and 36, Gresham-street, E.C.

Bristol.—At the last meeting of the Corporation, the Mayor moved "That the Council do adopt experimentally the alternate-current transformer system of lighting in the area included in schedule A of the Bristol Order, confirmed by the Electric Lighting Orders Confirmation (No. 9) Act, 1883." Mr. A. Baker said it seemed to him that the Electric Lighting Committee had not carried the matter so far as they ought to have done. Electric lighting was no longer a matter of experiment; and he moved as an amendment, "That it is desirable that the Corporation should keep the control of the supply of electricity for lighting and other purposes of the city in its own hands, and that the report be referred back to the committee, with instructions to advise the Council as to the desirability of adopting a scheme for lighting a larger area than that suggested, and for supplying private consumers with electricity." After a long discussion, the amendment was carried by 33 votes to 5.

Artistic Electric Lighting.—In his new house at 1, Queen's-gate-gardens, Mr. J. E. H. Gordon has, as might have been expected, made the utmost of the artistic possibilities of the electric light. The house is provided with about 115 lights, many of which are of high candle-power, and the fittings not only exhibit great originality, but are also of great variety. In the drawing-room for instance, the ceiling of which is panelled with gold Japanese embroidery, the room is illuminated by reflection, the light being thrown against the ceiling by four high candle-power incandescent lamps, beneath which is placed a mass of muslin held up by figures of flying storks. In another part of the same room a window of Cairene lattice work is lighted from the outside in the most artistic fashion. Wall plugs have been extensively employed, and it is possible to obtain the current for a portable lamp in almost any part of the house. The whole of the electrical fittings were carried out by Messrs. Faraday and Son, and the current is obtained from the Kensington Court mains, and the supply has given every satisfaction.

Obituary.—The death is announced on the 29th May of M. Daniel Napoli, head of the laboratory of the Eastern Railway Company of France. Born at Naples on the 27th April, 1840, M. Napoli came to Paris at an early age, and entered the employment of the Eastern Railway Company, as an apprenticed fitter, where his intelligence and great manual skill soon attracted attention. In the field of electricity M. Napoli was the inventor of several skilful contrivances, such as electric clocks and electric alarms. To him also were due some ingenious devices connected with the Regnier-Werdermann lamp. He took an active part in organising the first Electrical Exhibition of

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1881; and his work in connection with the Association Polytechnique gave valuable aid to the popularisation of science. M. Napoli was no mean sculptor, and several of his works found a place in the *Salon*; amongst which were busts of Ampère, Gramme, and Graham Bell. He was Chevalier of the Legion of Honour, officer of the Academy, President of the Société de Navigation Aérienne, and "Secrétaire-fondateur" of the Société Internationale des Électriciens.

Folkestone.—At the last meeting of the Town Council a lengthy discussion ensued on the reading of the report of the Electric Lighting Committee. From this it seems that the Corporation having objected to the streets being opened before October 1st, Messrs. Crompton and Co., the electric light contractors, stated that they could not get the light ready by January 1st. It was therefore resolved by the Committee that the Corporation should be recommended to alter the date for the commencement of the work in the streets from October 1st to August 1st. To this the contractors replied that if they could commence at once they would be ready with the light by January 1st; but as there would be some further delay, they felt it better to say at once that February 1st should be fixed as the day on which the lighting should commence. In reply to a further communication from the Committee the contractors said they could not now promise to be ready before February 1st. Mr. Thompson moved that the report of the Committee and the letter from the Company be received, and referred back to the Electric Lighting Committee, with power to arrange with Messrs. Crompton and Co. as to the date at which public lighting shall commence, and matters incident thereto. After great discussion Mr. Thompson's resolution was carried, subject to an instruction that the streets were not to be interfered with before October 1st.

The Australian Cable Rates.—Acting upon instructions recently sent to them by their Ministries, the Australian Agents-General had an interview, on Friday last, with the Financial Secretary to the Treasury, for the purpose of proffering the request that the Home Government should bear a share of the subsidies and guarantees granted by the Colonial Governments to the cable services from Great Britain to Australia, which subsidies will be considerably increased when the reduced rates come into force next January. Mr. Jackson is understood to have assured the colonial representatives that their views should be laid before Mr. Goschen, and that the matter would receive most careful consideration.—In the House of Commons on Monday night Mr. Summers asked whether, with a view of improving and cheapening communication between the different parts of the British Empire, the Government would consider the advisability of buying the cables of the Eastern Telegraph Companies, or of laying new cables to compete with those already in existence. In reply, the Chancellor of the Exchequer stated that Her Majesty's Government were not prepared to enter upon the wide question, involving, as it would, international negotiations, of buying up the cables of the Eastern Telegraph Companies, nor was it certain that their acquisition by the Government would lead to the desired results. But the Government would be glad if the labours of the International Telegraph Conference now sitting at Paris should have some result in the direction indicated in the question of the hon. member.

The British Association.—The programme for the Leeds meeting of the British Association has been issued. It commences on Wednesday, September 3, 1890. The president-elect is Sir Frederick Abel, F.R.S. The local secretaries for the meeting at Leeds are Mr. J. Rawlinson Ford, Mr. Sydney Lupton, Prof. L. C. Miall, and Prof. A. Smithells, and the local treasurer Mr. E. Beckett Faber. The presidents of the various sections are as follows:—A. Mathematical and physical science, Dr. J. W. L. Glaisher, D.Sc., F.R.S. B. Chemical science, Prof. T. E. Thorpe, B.Sc., F.R.S. C. Geology, Prof. A. H. Green, M.A., F.R.S. D. Biology, Prof. A. Milnes Marshall, D.Sc., F.R.S. E. Geography, Lieutenant-Colonel Sir R. Lambert Playfair, K.C.M.G. F. Economic science and statistics, Prof. Alfred Marshall, M.A. G. Mechanical science, Captain A. Noble, F.R.S. H. Anthropology, Mr. John Evans. The first general meeting will be held on Wednesday, September 3rd, at 8 p.m., when Prof. W. H. Flower will resign the chair, and Sir Frederick Abel, president-elect, will assume the presidency and deliver an address. On Thursday evening, September 4th, at 8 p.m., there will be a *soirée*; on Friday evening, September 5th, at 8:30 p.m., a discourse on "Mimicry," by Mr. E. B. Poulton, M.A., F.R.S.; on Monday evening, September 8th, at 8:30 p.m., a discourse on "Quartz Fibres and their Applications," by Prof. C. Vernon Boys, F.R.S.; on Tuesday evening, September 9th, at 8 p.m., a *soirée*; and on Wednesday, September 10th, the concluding general meeting will be held at 2:30 p.m.

Address to Sir James Anderson.—The following is the address presented to Sir James Anderson by the delegates assembled at Paris, on the occasion of his birthday on the 4th inst.:—

To Sir James Anderson.

We, the undersigned, attending the International Telegraph Conference in Paris, desire to take the opportunity of expressing to you our sincere and hearty congratulations on the occasion of your birthday and the fiftieth anniversary of the commencement of your first voyage—your jubilee of work and your golden wedding with the sea. We rejoice at your presence amongst us in the enjoyment of health and prosperity. We record our admiration of your long and successful career and high professional attainments as a sailor, and of the great services you have rendered in connection with the laying and repair of submarine telegraph cables in the deeper waters of the ocean. We wish also to express our warm appreciation of the ability and uprightness and unvarying courtesy and geniality which have distinguished your conduct of the business of the Telegraph Companies of which you have for many years been the Managing Director. We further congratulate you on the adoption by the present Conference of the project of an authorised International Vocabulary for telegraph messages, first proposed by you, and which you have for many years laboured to establish, believing, as we do, that this vocabulary will materially assist in securing the more speedy, accurate, and economical transmission of telegraphic communications in the future. With the assurance of our affectionate regard and high esteem, we wish you many years of continued usefulness and happiness.

John Pender, Thomas Fuller, C. W. Earle, A. J. Leppoc Cappel, William Ford, Charles Burt, W. Andrews, Alex. Wood, H. A. Mallock, Robt. Kaye Gray, Ernest Floyer, G. Von Chauvin, Jules Despêcher, R. T. Brown, Lewis Wells, Ch. Gerhardi, Wm. Payton, R. M. Cunningham, Jas. Scott, W. F. O'Brien, F. E. Hesse, G. Serpos, W. Hibberdine, P. Gatliff, T. A. Bullock, F. Moll, G. R. Neilson.

The County Council and Overhead Wires.—The Bill of the London County Council which asks the sanction of Parliament for powers to control overhead wires, came before a Select Committee of the House of Commons, under the presidency of Sir Joseph Bailey, on Wednesday. Mr. Pember, Q.C., addressed the Committee in favour of the scheme. The Bill, he said, was founded on a report made by a Committee to the House of Commons in the year 1885, which was appointed to consider the law in regard to telephone, telegraph, and other wires. That Committee came to the conclusion that the danger from overhead wires had been greatly exaggerated, and that accidents were few; but it was of opinion that, having regard to the increase of the telephonic system, it was desirable that a change in the law relating to the suspension of such wires should be made, but that it was not desirable that any course should be pursued which would hamper the extension of telephonic systems. Mr. Pember pointed out that if an alteration in the law was deemed necessary in 1885, it would necessarily be more so at the present time, owing to the great increase in the number of wires. Having read the Bill, he said he hoped he had proved to the Committee that it was in accord with the recommendations of the Committee of 1885; but if in any point it had gone beyond it, the five years that had elapsed had probably made that necessary. With regard to the opposition of the National Telephone Company, the Bill had been greatly modified in order to fall in with the views of that Company; but there were still points upon which they had not been able to agree, and if they were unable to do so before the conclusion of the inquiry, the Committee would have to decide the difference between them. The opposition of the Electric Supply Companies was passed over for the time to see whether an arrangement could not be arrived at. Mr. Pember then addressed the Committee on the opposition of the Corporation of London, which, he said, was desirous of retaining the control of all wires passing through the City. Evidence was then taken in support of counsel's statements.

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ON THE PERMEABILITY OF IRON AT RIGHT ANGLES TO THE DIRECTION OF MAGNETISATION.

BY A. E. KENNELLY.

(*Concluded from page 114.*)

The theoretical relations existing between the inductances may now be considered.

Let a magnetising force, H, act upon a portion of homogeneous iron in the direction of x, a rectangular co-ordinate axis, and induce a magnetisation of amount I in the same direction, according to the relation $\mathsf{I} = f(\mathsf{H})$, then the induction per unit area $\mathsf{B} = \mathsf{H} + 4\pi f(\mathsf{H})$, and a closed solenoid surrounding a ring of this iron will, when measured with feeble currents, show an inductance L_x, expressed by the relation $L_x = l \frac{d\mathsf{B}}{d\mathsf{H}}$, l being the coil's inductance in a medium of unit permeability. Hence, the locus of L_x referred to H, should be a curve whose ordinates are proportional to $\frac{d\mathsf{B}}{d\mathsf{H}}$ at every point.

If, now, H receive a small increment, $d\mathsf{H}$, at right angles, or parallel to the y axis, then, provided that the iron is isotropic, the resultant magnetic force will lie in the plane $x\,y$, and make an angle, $\tan^{-1}\frac{d\mathsf{H}}{\mathsf{H}}$ with x. The component magnetisation, $\mathsf{I}\,y = \frac{d\mathsf{H}}{\mathsf{H}} f(\mathsf{H})$, the corresponding induction, $\mathsf{B}_y = d\mathsf{H} + 4\pi \frac{d\mathsf{H}}{\mathsf{H}} f(\mathsf{H})$, and the apparent inductance of the original solenoid, $L_y = l \frac{d\mathsf{B}_y}{d\mathsf{H}} = l\left\{1 + 4\pi \frac{f(\mathsf{H})}{\mathsf{H}}\right\} = l\mu$, where μ is the permeability of the iron in the direction x. The locus of L_y referred as before to H, will have its ordinates everywhere proportional to μ.

If, however, the iron is æolotropic, the magnetisation along y will be some function $\phi(\mathsf{H}, d\mathsf{H})$ of both H and $d\mathsf{H}$, so that any evident divergence between these two curves of L_y and μ, shown by experiment, marks the departure of the iron from the initial isotropic state in corresponding degree.

The results given in Tables III.—VI. are plotted in Figs. 2, 3, and 4. Examination of these curves shows:—

1st. That the curves of $L\,x$ do not indicate the very sudden rise in the value of $\frac{d\mathsf{B}}{d\mathsf{H}}$ known to take place within the first 10 units of H. This may, perhaps, be accounted for by supposing that at this stage the iron molecules are in a critical magnetic condition, and that the feeble magnetic force in the inductance test is insufficient to precipitate them.

2nd. That after H exceeds some 30 units, $L\,x$ appears in each case to be greater than $\frac{d\mathsf{B}}{d\mathsf{H}}$. This can only be attributed to error in the observation or method.

3rd. That in Figs. 3 and 4 the curves of $L\,y$ for values of H not less than 50 are rather more divergent from those of μ than $L\,x$ from $\frac{d\mathsf{B}}{d\mathsf{H}}$.

4th. That in Fig. 2, the case of wrought iron, there is a marked discrepancy between the two curves $L\,y$ and μ, the former being considerably in excess for magnetising forces above 20. The point of abrupt change of curvature in $L\,y$ appears to take place at a magnetising force of 9; and this, by a curious coincidence, is the value given by Mr. Shelford Bidwell for the "Villari critical point" in a particular instance.

While, therefore, the results with the rings of cast iron and tool-steel are doubtful, it may be safely inferred that the sample of wrought iron distinctly indicated æolotropic behaviour for magnetising forces exceeding 30 units; and this is not unreasonable when we remember that, according to Dr. Hopkinson, iron attains its maximum length at a magnetic force of 20. The contraction which sets in after that point may do such work against intermolecular forces as will by reaction affect the ratio $\frac{f(\mathsf{H})}{\mathsf{H}}$, or κ.

If this be admitted, Weber's theory cannot be regarded as theoretically correct for values of H exceeding 30, and beyond that point, at least, any strict theory of magnetisation must involve a consideration of molecular stresses and displacements.

Weber's theory, however great a stride over pre-existing conceptions, and however completely it enabled existing knowledge to cope mathematically with the intricate phenomena of magnetisation, is based upon what appears to be a very arbitrary hypothesis. It is assumed that the restituting force on the molecule varies directly with the sine of the displacement angle. The mechanism by which any such forces—magnetic or mechanical—could be exerted, unless as the result of some underlying hypothesis, is difficult to imagine. The amendments that Clerk-Maxwell introduced to enable it to cover the phenomena of hysteresis and permanent magnetisation, ingenious as they are, must also be confessed as very arbitrary. While his limitations of strain and "set" in the rotation of the molecules are, perhaps, the only ones capable of yielding a mathematical solution moderately simple, yet rationally complete, it tasks the imagination to suggest why just those particular limitations should naturally suggest themselves.

Moreover, the appearance in certain conditions of a stage of magnetic instability at which the ratio of magnetisation to magnetising force suddenly becomes discontinuously great, such a condition as has been observed by several physicists and lately pointed out by Professors Ewing and Thompson, cannot be accounted for by the Weber-Maxwell theory in its existing form, which only admits of continuous changes.

It is usually much easier to discover imperfections in existing theories, than to replace them by others less objectionable; but the following theory is offered as a suggestion. It is in reality only an adaptation of that promulgated by Prof. D. E. Hughes in his Papers to the Royal Society ten years since. In the following form, while embracing all those phenomena that Weber's theory explains, it has the advantage of explaining the stage of molecular instability, without being cumbered by special inherent limitations in the direction and magnitude of the restituting forces. At the same time it has the disadvantage of so attempting to portray the operations concerned in magnetisation, that a complete mathematical solution of the phases in transition is at present apparently beyond reach. It is also subject for its existence to the admission of an unusual postulate to be later specified. We may call it the "chain" theory of magnetisation.

Suppose the iron to be homogeneous, and to have n molecules per unit volume. As in Weber's theory, let the magnetic moment of each molecule be m, which varies only with the temperature. The maximum magnetisation possible is then

$$\mathsf{M} = n\,m.$$

In virgin iron under no magnetic influence, these molecules will be so arranged that there will be no resultant magnetisation. This we may suppose to result, not from any indiscriminate scattering of the magnetic axes in space, but from the formation under mutual attractive influences of closed loops or chains in the molecules. These chains may interlace in every conceivable manner, some may bifurcate or trifurcate in parts; but the characteristic feature of the magnetic arrangement in soft virgin iron will be the existence of magnetic chains made of two or more and usually many molecules as the rule, and the existence of unchained molecules isolated exceptions whose unstable condition renders them likely to fall into and form an offshoot loop of the nearest chain upon the slightest impulse. Let it also be granted that the seat of magnetic force is at the two extremities or poles of a magnetic axis connecting them fixed in the molecules and of length l, while the average distance d, intervening between the opposed poles of adjacent molecules in a chain is small compared with l. It may be remarked that this assumption is not equivalent to making the average intermolecular distance small compared with the dimensions of the molecule; for in the absence of knowledge concerning the nature of molecules, we are at liberty to place their poles in their "ether envelopes," or external it may be to their own proper space, provided that their poles are in rigid connection with them. The tendency of the magnetic

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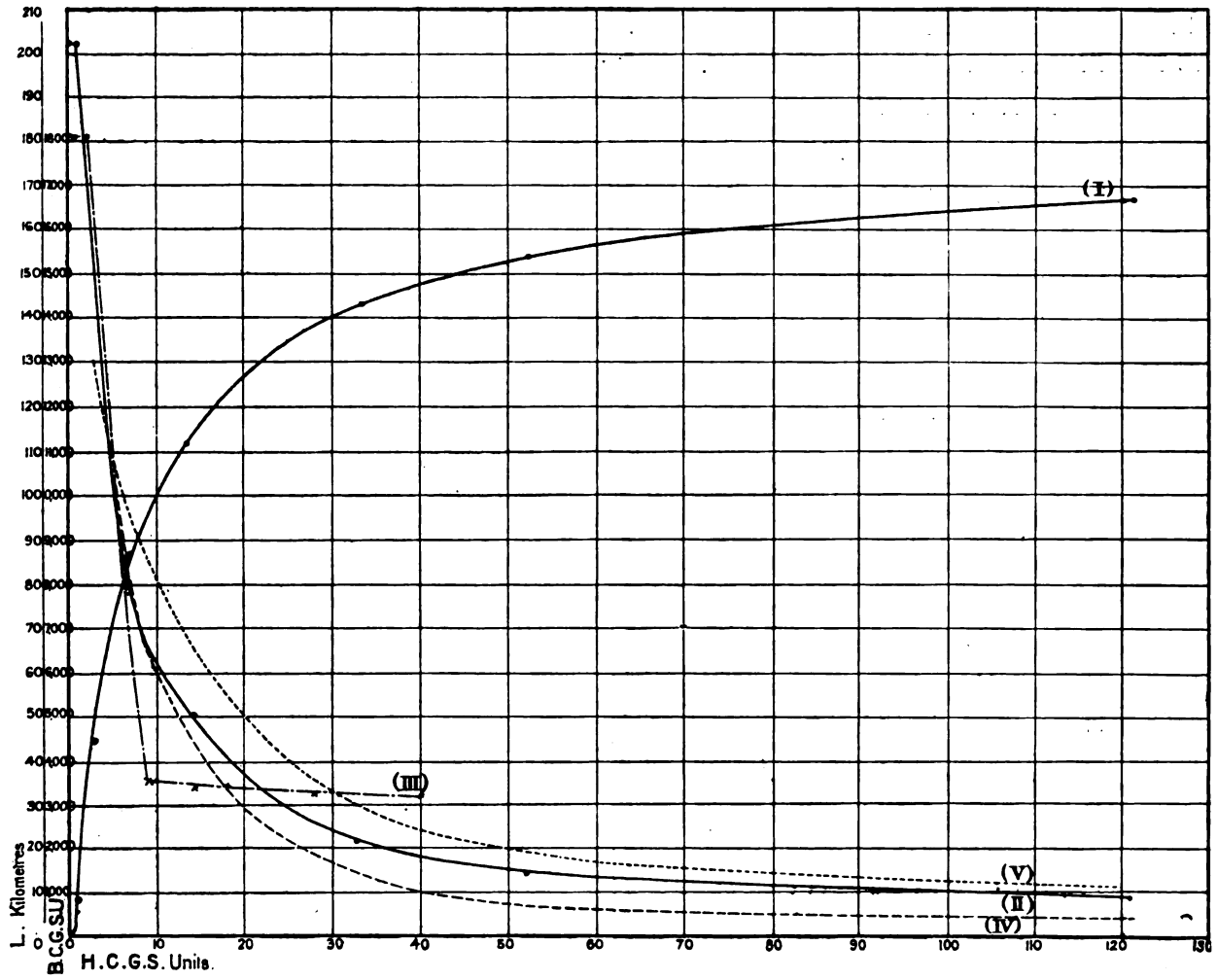

FIG. 2.—Wrought Iron Ring.

(I) ——— Ascending curve, **B**, or induction.
(II) ——— Descending curve, L_x, or inductance of coil in kilometres under parallel magnetisation.
(III) —·—·— Curve of L_y or inductance of coil in kilometres under magnetisation at right angles.
(IV) — — — Curve whose ordinates are proportional to $\frac{d\,\mathbf{B}}{d\,\mathbf{H}}$.
(V) ····· Curve whose ordinates are proportional to μ, or $(1+4\pi\kappa)$.

(II) should coincide with (IV), and for isotropic iron (III.) with (V).
Ordinates of (I), C.-G.-S. lines per square centimetre of cross section to right-hand scale.
„ (II) and (III), observed inductance of coil in kilometres to left-hand scale.
„ (IV) and (V) are numerically comparative, and not in absolute measure.
Abscissæ, magnetising force **H**, in C.-G.-S. units for all curves.

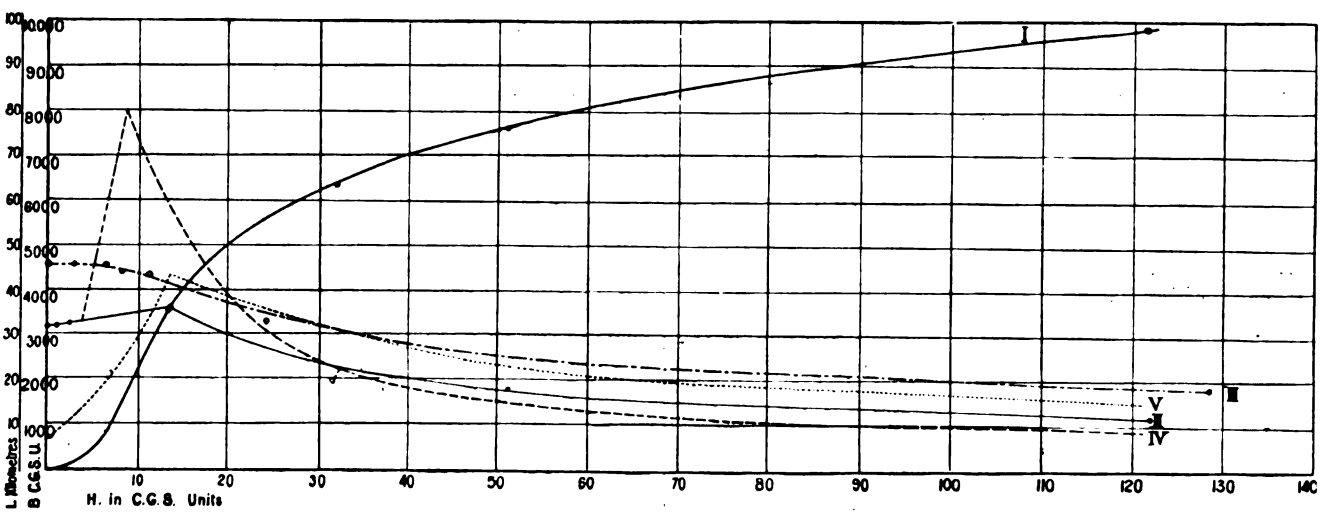

FIG. 3.—Cast Iron Ring.

(I) ——— Ascending curve, **B**, or induction, in C.-G.-S. lines per square centimetre.
(II) ——— Descending curve, L_x, or observed inductance of coil under parallel magnetisation.
(III) —·—·— Curve of L_y, or observed inductance of coil under transverse magnetisation.
(IV) — — - Curve whose ordinates are proportional to $\frac{d\,\mathbf{B}}{d\,\mathbf{H}}$.
(V) ····· Curve whose ordinates are proportional to μ, or $(1+4\pi\kappa)$.

Ordinates for (I), C.-G.-S. lines to right-hand scale.
„ (II) and (III), inductance in kilometres to left-hand scale.
„ (IV) and (V) are numerically comparative, and not in absolute measure.
Abscissæ for all curves, **H** in absolute units.
(II) should coincide with (IV), and for isotropic iron (III) with (V).

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chains is to contract and reduce d, a tendency resisted by those forces which regulate the proportions and play of the molecular structure. This granted, it is easily seen that the magnetic moment of any one chain about any diameter as an axis will be small in relation to the moment of the molecule, while the chains being in all curvatures and azimuths, their aggregate moment in the mass must be vanishingly small.

Considering a single molecule in any chain, if r be the distance from one of the poles to any other pole in the mass, the magnetic force exerted between them will be a vector force ρ, expressed by the relation $\rho = m^2 f(r)$, where $f(r)$ may or may not be the function of inverse squares holding for sensible distances. Then the forces which are active in determining the direction of our selected molecule, assuming it to be free to turn on its centre in any direction, but to have the position of its centre prescribed by structural forces, will be two resultant magnetic forces, viz., $\Sigma \rho_p$ on the positive, and $\Sigma \rho_n$ on the negative pole, the summation being made vectorially and extended to every pole in the whole system. Since, however, d is small compared with l, the effect of the sphere of attractive force is practically confined to the nearest one or two molecules along the chain, while the influence of neighbouring molecules in other chains is a disturbing force generally small.

These two forces, $\Sigma \rho_p$ on p the positive pole, and $\Sigma \rho_n$ on n the negative pole, will be equivalent to a uniform magnetic field vectorially h say, acting on our molecule in the direction of its axis, and a single force, vectorially ϕ acting upon the molecular centre, tending to give it a motion of translations which tendency is presumed to be held in equilibrium by the mechanical forces of the molecular framework. This equivalent field h, and single central resultant ϕ, will exist for every molecule; and with reference to the chains, each h will be approximately tangent to the radius of curvature at that point, while ϕ will be directed towards the interior of the chain.

If now a vector magnetising force H be brought to bear upon the system, every molecule whose axis is not parallel to H will be magnetically deflected. Considering any single molecule, if its h remained constant, then its new axial position vectorially λ say in space would be in the resultant of h and H, or in line with the vector $\mathsf{H} + h$; but since nearly every molecule which previously contributed towards its h has also slightly deflected, the real new axial position will be in the vector line $\lambda = \mathsf{H} + (h - \Delta h)$, Δh representing the secondary disturbing effect on h.

The angle of deflection included between h and λ will vary for each molecule from zero for those originally in line with h to a maximum for those whose axes were originally nearest to a right angle with H. It is to be noticed that no matter what angle each chain might individually make with H, in parts or in planes, there will be always two and often more than two molecules opposite in each chain originally set so nearly perpendicular to H that their deflections in that chain are a maximum. Let us call these favoured molecules of a chain the "leaders."

Then if the chains were all composed of the same large number of molecules and similar in every respect, so arranged that however intimately they might be interlaced, no two chains ever approached within the sphere of mutual disturbing influence, the deflection of all the leaders would be equal, independent of the angle between their respective chain planes and H, for with all leaders h and H would be at right angles, h would have a common value, so also would Δh, and thus the deflection of each would be $\tan^{-1}\left(\frac{\mathsf{H}}{h - \Delta h}\right)$.

It may readily be granted that what would then be rigidly true for an ideally homogeneous system is nearly true by the theory of probabilities in a system partly subject to homogeneity, and partly left to fortuitous combinations, so that the

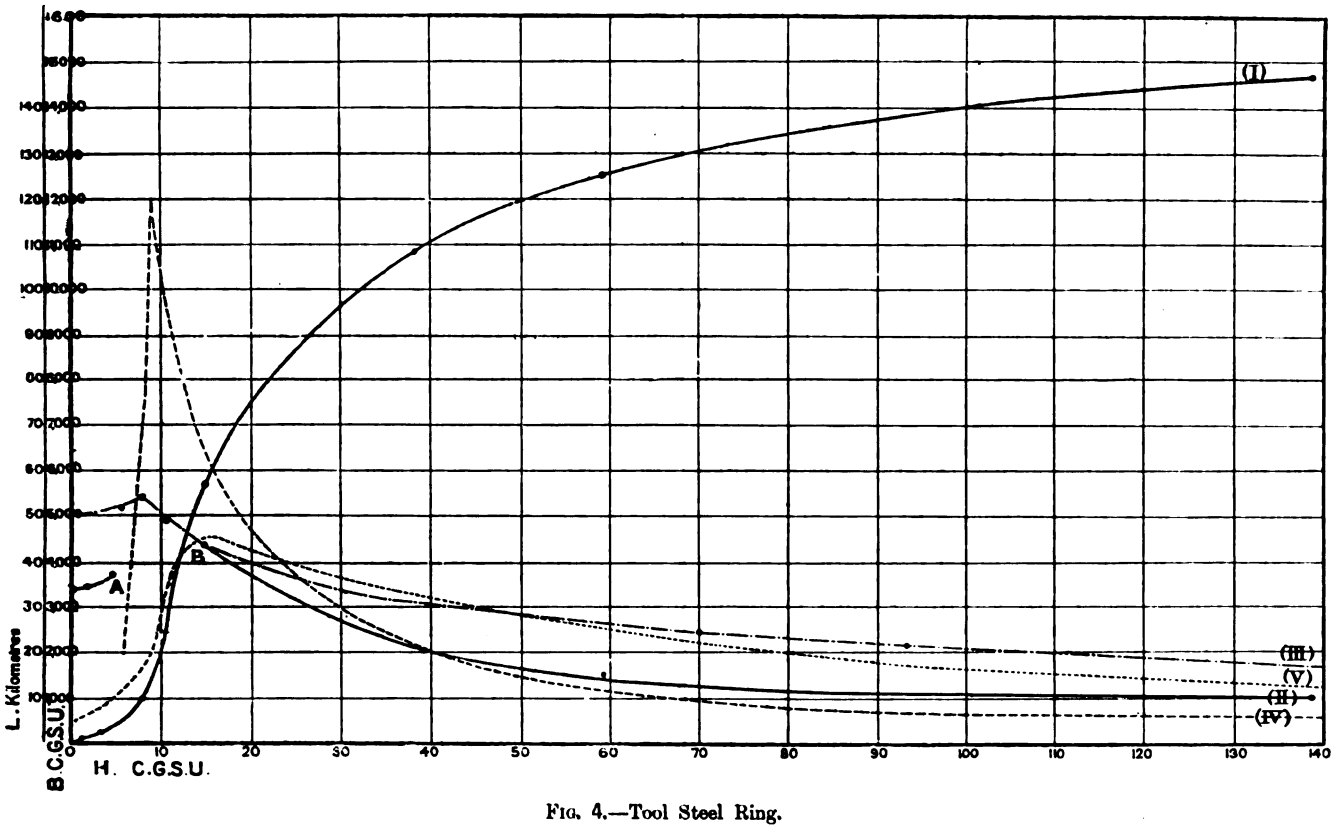

FIG. 4.—Tool Steel Ring.

(I) ———— Ascending curve, B, or induction.

(II) ———— Descending curve, L_x, or observed inductance of coil under parallel magnetisation.

(III) —·—·— Curve of L_y, or observed inductance of coil under transverse magnetisation.

(IV) — — — Curve whose ordinates are proportional to $\frac{d\mathsf{B}}{d\mathsf{H}}$.

(V) ····· Curve whose ordinates are proportional to μ, or $\frac{\mathsf{B}}{\mathsf{H}}$.

(II) should coincide with (IV), and for isotropic iron (III) with (V).

Ordinates for (I), C.-G.-S. lines per square centimetre, right-hand scale.

" (II) and (III), observed inductance of ring in kilometres, left-hand scale.

" (IV) and (V) are numerically comparative, and not in absolute measure.

Abscissæ, magnetising force H, in C.-G.-S. units for all curves.

N.B.—The course of Curve (II) between the points A and B has been omitted as doubtful.

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maximum deviation would be nearly alike in all chains and equal to the average value of $\tan^{-1}\left(\frac{H}{h-\Delta h}\right)$.

As H is now gradually increased all the deflections increase, but the increase is most rapid in the leaders, to which we may, therefore, confine our attention. If h were constant, the restituting moment due to h would increase with the angle of deflection; but owing to the secondary disturbance Δh, this moment does not increase in proportion to the moment of deflection due to H. This continues until h has been so much reduced by Δh, that a critical point is reached, and first reached in the leaders, when an increment in H, and therefore in the deflection, makes the restituting moment—just previously a maximum—diminish. At this stage nearly simultaneous with all the chains, the leaders break from their neighbours and rotate into parallelism with H. These neighbours, whose deflections had been next greatest in value, suddenly deprived of support, suffering a large increase in Δh, are precipitated into dislocation, and the example thus set is followed under transmitted influence all along the line till it terminates at the motionless molecules or nodal points originally parallel to H. The desertion of the leaders is thus the signal for the immediate disruption of the chains, which vanish without leaving a trace of their existence, and it may be that on the subsequent complete withdrawal of H, the associations, arrangement, and chains formed by the molecules under their once more ascendant mutual attractions may totally differ from those gone by.

If now elastic resistance to rotation be introduced as a factor, together with the stresses affecting the isotropic condition of the medium, the materials are present for suggesting every known description of paramagnetisation.

A few of the leading consequences of the theory may be outlined as follows:—

With a homogeneity of chain formation in marked degree, and very small resistance to rotation, the critical stage should be very pronounced, especially if the stresses produced by the magnetisation are either absent or removed by opposite imposed stresses. Such magnetisation would be almost entirely temporary, and there would be no coercive force. On first applying magnetic force, there would be a period of steadily increasing feeble magnetisation, then a sudden bound of almost complete magnetisation, followed by no subsequent change with any increase in magnetic force.

If, in the next instance, elastic resistance to rotation were introduced, the first stage of feeble magnetisation would not sensibly differ, and the critical stage would be reached at the same force, but the magnitude and duration of the bound would be modified in proportion to the resistance. The molecules would be retarded, and the chains might not instantly or coincidently break up on the departure of their leaders. Even after the disappearance of the chains, infinite magnetic force would be needed to produce in every molecule an indefinitely close convergence to parallelism, and the parallelism once produced would be more or less subpermanent.

Finally, as reaction stresses and want of chain homogenity are introduced, the critical stage in the magnetisation, although never entirely effaced, is more and more concealed, and the curve of $\frac{dB}{dH}$ shows a lower and less tapering apex.

Between these limits, all the characteristics of magnetised iron seem to be included.

As regards the stresses produced in iron by the process of magnetisation, we should expect to discover a voluminal expansion up to the critical stage owing to the reduction of the ϕ forces, which in the virgin state are directed towards the chain centres as already noticed. Once the critical stage is reached, however, there should be a linear shrinkage in the direction of H, accompanied probably by an expansion in all directions at right angles, owing to the mutual attraction of all the consecutive polarised molecules. This shrinkage should be instantaneous and final in ideally soft and homogeneous iron, while it would be gradually affected to an equal limiting amount in iron subject to elastic resistance.

This deduction appears to agree fairly with the observed facts, so far as they are recorded for iron, but the anomalous behaviour of cobalt and nickel in this respect has yet to be accounted for; and in fact, as Dr. Hopkinson pointed out in his able address to the London Institute of Electrical Engineers this year, no theory of magnetisation can ever be considered complete until the origin and phenomena of molecular polarity, the essence of the whole subject, are satisfactorily explained.

THE WESTINGHOUSE CONSTANT-CURRENT ALTERNATING SYSTEM.

By constant current in this connection it will be understood that the value of the alternating current as measured by a dynamometer, or the square root of the mean square of the periodic current, is a constant quantity.

In *The Electrician* of April 25th a description of the new Westinghouse arc light system was reproduced from the *Electrical Engineer* of New York, with some illustrations showing the general appearance and construction of the armature of the generator; also a table and curves of efficiencies attained. The additional information with regard to this system contained in the following notes may, however, prove of practical interest.

The objects which the Westinghouse Company had in view in this system were—first, to enable them to build larger machines for arc lighting (and thus increase the size of the plant unit) without unduly increasing the potential of the current; and, secondly, to enable them to insulate the lamps themselves from the high-tension mains. It is evident that a constant-current system must necessarily be a series system, if there is to be any variation in the load; and the present system is one in which the converters are connected in series with the line. Constant current in the primary of a converter means that if the windings are as 1 to 1 the current in the

Fig. 1.—10-Ampere Circuit.

secondary is absolutely limited to a value a little below that of the primary current; or, if the windings are as 1 to 3, for instance, then the current in the secondary is limited to slightly less than one-third the primary current. This limitation of the strength of current, combined, as it necessarily is, with a very rapid rise of volts in the secondary if the current falls in consequence of an increase of resistance in the secondary circuit, is precisely what is wanted to ensure stability and consequent absence of flickering in arc lighting resistance coils such as are required in all cases when arc lamps are run on constant potential circuits being of course dispensed with. The system is intended more especially for street lighting; but in America private users are also supplied by it When the number of lamps required on a single circuit does not exceed 60, a current of 10 amperes is employed, in which case the converters can be dispensed with altogether in the case of street lamps, if no objection is made to their being in connection with the high-tension mains. In American towns and cities, where this system has been adopted, private users have also been allowed to have lamps supplied direct without the use of converters if they wish to avoid the cost of the converter, and accept the risk as regards the high tension.

Fig. 1 is a diagram of a 10-ampere circuit. A A A represents private consumer's lamps supplied with the use of converters. B B represents private consumers who accept the risk of the high-tension mains coming into their premises. C C represents street lamps with converters, and D D street lamps connected directly in series with high-tension mains. The larger machines at present constructed have capacities of 120 and 240 lights respectively, and employ a current of 30 amperes, the larger of the two machines having two independent circuits. This

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current is much too large for street lamps, so that the facility of connecting lamps directly in series with the mains is practically lost in the case of the larger machines.

Fig. 2 is a diagram of a 30-ampere circuit. A represents two lights, B one light, and C three lights, run from converters for private consumers. E E E represents street lamps also run from converters.

The exciting magnets, and also the external appearance of the constant-current machines, are similar to those of the Westinghouse constant potential alternators, the difference being in the construction of the armature (see *The Electrician*, April 25th), which is provided with large overlapping teeth, slightly wider than the gaps between the field poles, so that

Fig. 2.—30-Ampere Circuit.

the edge of one tooth comes under a magnet pole just before another has entirely left. The teeth are equal in number to the field poles, and each tooth carries a constituent coil of the armature winding. No regulating apparatus whatever is employed to keep the current constant, the machine being so designed that the magnetic flux through the armature, and consequently the E.M.F. generated, is practically proportional to the resistance in circuit. Although the action of the machine is well described in the latter part of the reprint referred to above, the following description, with the aid of the sketches Figs. 3, 4 and 5, may give a clearer insight into the way in which self-regulation is secured. The proportion of the winding of the armature to that of the field coils is such that at the moment of maximum current the ampere turns of the armature coils are approximately equal to those of the field coils, and consequently if the armature current reaches its maximum at a moment when the teeth approach coincidence with the poles the magnetic flux will be very small and the E.M.F. generated only just sufficient to send a harmless current through the armature when short-circuited. In Fig. 3 the

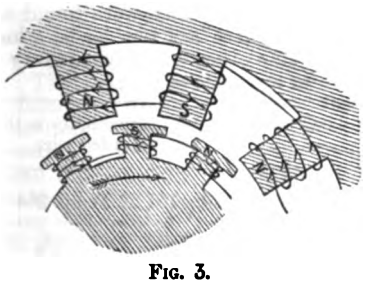

Fig. 3.

armature teeth are shown in the position midway between the field poles, and, as is well understood, the induced E.M.F. will be at a maximum in this position. If no current is allowed to flow, the field coils produce a large magnetic flux, and a high E.M.F. is generated which in the machines as constructed may reach 10,000 volts or so. It is therefore advisable for safety to short-circuit the armature when running without load, and an automatic arrangement is provided on each machine to effect this. If, now, the armature circuit is closed with a moderate resistance in circuit the lagging of the current behind the impressed E.M.F. causes the armature teeth to have made an approach towards coincidence with the magnet poles (*see* Fig. 4) at the time when the current in the armature coils has reached its maximum value. This approach towards coincidence considerably increases the self-induction of the armature by improving the magnetic circuit, which has the effect of making the lag much greater than it would have been had the self-induction of the armature remained constant; so that by a cumulative process the lag due to an increase of current in the armature winding is considerably magnified. The approach towards coincidence between the armature teeth and the magnet coils at the moment of maximum current also has the effect of directly cutting down the E.M.F. by bringing the magnetising force of the armature winding into more direct opposition with that of the field coils, and thus reducing the magnetic flux through the armature, until when coincidence is practically reached (see Fig. 5)—as it is when the armature is short-circuited—the armature and field windings oppose each other on very nearly equal terms, and the magnetic flux is only sufficient to cause a slightly increased current in the armature. In the machines as constructed, if the resistance inserted consists of a load of converters in series, with arc lamps in their

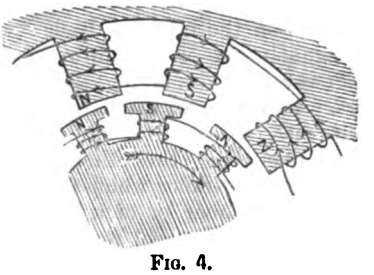

Fig. 4.

secondaries, the lag due to the current flowing in the armature will be such that the magnetic flux due to the resultant of the magnetising forces of the field and armature coils will be of the value necessary to produce the normal volts for that particular load, and the Westinghouse Company claim to have succeeded in turning out machines so sensitive that a practically negligible variation in the current causes a variation of E.M.F. in the external circuit from nil when the armature is short-circuited up to 2,000 or 3,000 volts when loaded up with converters and arc lamps. It is stated that the full load can be suddenly thrown on or off without doing any damage to the machine, the current remaining practically steady during either operation. The 240 light machines, as has already been stated, are two circuit machines, and are generally employed in large towns and cities for street lighting, where there is not much variation in the load, when it is found that the interference between the two circuits is not noticeable. It is, of course, impossible that the two circuits should regulate independently.

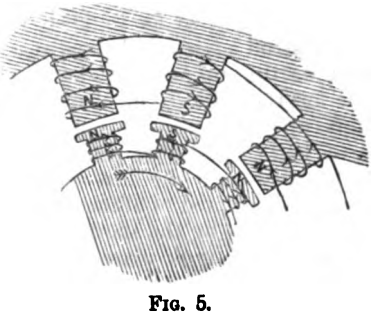

Fig. 5.

The transformer employed is a closed circuit one. Lamps are extinguished by short-circuiting the *secondary* coil, a proceeding which causes very little waste of energy, owing to the low value reached by the induction in the iron and the small resistance of the copper circuit. The results of the secondary being on open circuit would be to cause heating of the core, due to the high value reached by the induction, and to choke the primary. To insure perfect insulation between the primary and secondary coils, they are wound on separate bobbins, with a considerable space between the two. The slight loss of efficiency resulting from this arrangement is said to be of little importance in a series arc system. The space between the coils and the cover is filled up with wood blocks and insulating compound, the object of the latter being to keep out damp; the practice is one which we think will hardly be regarded with favour by English electricians.

With regard to the arc lamp, the only new point which has not been already described in these pages is the addition of a small reflector around the upper carbon to throw the rays from the lower carbon crater in a useful direction.

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THE STORAGE CELLS AT THE CHELSEA ELECTRICITY SUPPLY COMPANY'S SUB-STATIONS.

In the article on the above Company's station and sub-stations which appeared in our issue of May 30 we confined ourselves to a general description of the plant and working arrangements. We now give some particulars of the method adopted of mounting and starting the storage cells, and of their present condition.

Those who have had to do with storage cells are sufficiently familiar with the difficulties of handling them; and any practical person can get a fair idea of these difficulties by picturing to himself a glass box on the top of a high shelf, full to the brim with a strong solution of sulphuric acid, in which is immersed about 2cwt. of lead plates. Added to this is the fact that the storage battery man has to deal not with one cell standing by itself with space all around it, but with tiers of shelves arranged one above the other, on which cells are packed with the smallest clearance which safety considerations will allow. A slip of a spanner, or of a ladder, or of the suspension hook of the traveller, might result in the shelves and connections beneath being deluged with 10 per cent. solution of sulphuric acid. It will be seen, then, that the overhauling of a cell is a matter requiring time and care for its execution; and the fact, stated by the Company's engineer, that two men have been found sufficient to do all that has been necessary for three sub-stations, having an aggregate of 1,365 cells, is *primâ facie* evidence that up to the present the amount of attention required by the cells is not great.

The cells are supported by upright frames of cast-iron, between which are fixed wooden bearers of a length sufficient to take, in some cases three, and in others four cells in a row. The ironwork is served with three good coats of red paint, and the wooden bearers with an equal number of coats of shellac varnish, while the spaces between the ends of the bearers and the ironwork are filled up with a mixture of bitumen and tar, with the object of preventing spilled acid or the spray which is caused by the breaking of the gas bubbles from getting between and causing destruction of wood and iron alike. Each cell stands upon a wooden tray filled with sawdust, which is supported by four Johnson and Phillips oil insulators, which rest upon the wood bearers above described. As far as is practicable, the cells are arranged so as to keep the difference of potential between those on adjacent shelves at a low value.

The time of first starting up a storage battery is well known to be a critical one for the cells. The charging ought to commence immediately after the acid is poured in; but as this process of filling a large number of cells necessarily occupies several hours, in practice only the last cells filled have this advantage. The method adopted of filling up the large number of cells at each sub-station in the shortest possible time has been to provide a lead-lined tank above the level of the cells into which the acid is poured direct from the carboys. An india-rubber hose is connected to the tank, by means of which the cells are filled in rapid succession. The filling of the cells at Clabon Mews occupied about six hours, after which charging was continued for upwards of thirty hours without cessation. This battery has now been in constant use for fifteen months, and at the time of our visit had the appearance of being in good order; nor were any of the well-known signs visible—in the shape of bent lugs or other unavoidable marks—of cells having been taken out and overhauled. The negative plates were scaling to some extent, and we noticed some positive plates which appeared to have lost some of the paste from the surfaces of the squares; but the space which is now provided at the bottom of the cells prevents the falling scale from giving trouble by shortcircuiting. We saw no signs whatever of buckling of the plates; and the opinion we formed after a close and careful inspection was that the battery was in thoroughly good working order. It may be mentioned that the back E.M.F. cells are generally made up with grids only, pasted plates being put into a sufficient number of cells to supply the current required for the various automatic apparatus.

Our account of this Company's station would be incomplete without mention of the name of Mr. Frank King in connection with the inception of the system and the ingenious automatic devices which distinguish this Company's system of supply from any other at present in operation. The fact that these devices have now been working without a hitch for several months must be highly satisfactory to him as the person responsible for their design and manufacture, especially when we remember the doubts expressed by many at the time when Major-General Webber described the arrangements at the British Association last year as to the possibility of a system which appeared so complex on paper proving successful in practice. The whole of the batteries and the automatic accessories were, we may add, manufactured and supplied by the old E. P. S. Company; and the extensions now in progress are being carried out, under Mr. King's supervision, by the successors of the E. P. S. Company, the Electric Construction Corporation, who are the owners of the patents in connection with this system.

THE PHYSICAL SOCIETY.

At the meeting of this Society held on the 6th inst., Mr. H. TOMLINSON read a Paper

"On the Effect of Change of Temperature on the Villari Critical Point of Iron"

The author observed that as in his former Paper (see *The Electrician*, April 4, 1890, p. 547), the temporary magnetisation only was considered, and the method of observation was the same as previously described; but he had now examined the effect of loading at various temperatures, extending up to 285° C. The temperature was determined by means of a coil of platinum wire wound double over the same part of the iron as the secondary coil, the temperature coefficient of this platinum coil having been previously determined. The iron wire, one millimetre in diameter, was thoroughly annealed, and the loads employed were not sufficient to produce any sensible permanent extension.

In the first instance the wire was heated to 300° C., and tested at the various load and magnetising forces at this temperature, and again after cooling to the temperature of the room, and this was repeated several times until constant results were obtained. The results of the observations were plotted as curves, the abscissæ of which represented the load in kilogrammes, while the ordinates represented the percentage alteration in permeability. The Villari critical point, or the value of the magnetising force for which loading does not affect the permeability, was given by the point of intersection of each curve with the load-line, and it was found to vary both with the load and the temperature. In some cases the curves which were exhibited to the Society were found to cut the load-line twice, showing that there are two loads, which, for certain magnetising forces, have no effect on the temporary magnetisation. These loads are given in the table below :—

—	Load for which the permeability is the same as for the unloaded wire.			
Magnetizing force in C.G.S. units.	Temp. 76° C.	Temp. 167° C.	Temp. 244° C.	Temp. 285° C.
2·84	5·0	5·3 12·0	5·7 10·0	
3·70	3·2	3·6	4·2 11·5	4·7 9·9
4·83	2·5	2·7	Not tested.	3·1 12·3

It follows, therefore, that all magnetising forces between 2·84 and 4·83 are Villari critical values. Regarding only the first point at which each curve intersected the line of loads, the observations showed that, at all temperatures, the Villari critical value increases as the load decreases, and for a given load increases with the temperature. Considering also the second point of intersection, they show that the Villari critical value increases both with the load and with the temperature, so that the effect of change of temperature on the critical value is in the same direction for both points of intersection, and therefore in both cases the critical value increases with the temperature. The curve showed that as the temperature increases the two points of intersection with the load-line gradually approach each other, until, at a temperature a little below 285° C., they coincide, and the curve osculates the load-line, while at higher temperatures than this the magnetising force 2·84 ceases to be a Villari point for any load. When the magnetising force attains the value 7·69 both points of intersection vanish, for loads up to 12 kilogrammes, though the second point would probably be obtained by taking

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sufficiently high loads. Below this limit, therefore, as regards the load, Villari points are impossible for magnetising forces beyond 7·69. Rise of temperature was found invariably to increase the change of permeability in the positive direction, and to diminish it in the negative direction ; but the diminution was greater than the increment, so that the two bends in the curves tended to approach the same level.

The percentage alteration of permeability was calculated in the following manner. Let P_o be the temporary permeability when unloaded, and P_n the permeability with a load of n kilogrammes, then the percentage alteration is—

$$\pm\frac{100\,(P_n - P_o)}{P_o},$$

the upper sign indicating that loading increases the permeability, and the lower one that it decreases it. The table below gives the values of P_o for the various temperatures and magnetising forces at which the observations were made.

Magnetising force in C.G.S. units.	Values of P_o.				
	12° C.	76° C.	167° C.	244° C.	285° C.
2·84	301	306	338	353	385
3·70	325	340	383	385	405
4·83	347	366	413	...	461
7·69	478	483	548	...	557
10·40	528	573	638	...	675
15·32	522	...	...	...	617

A Paper, by Messrs. W. G. Robson and S. W. J. Smith,

"On the Diurnal Variations of the Magnet at Kew,"

was then read.

The authors considered that the multiplication of magnetic observations made it highly desirable that the methods of reducing the observations should be as similar as possible. It was, however, practically impossible for all observatories to determine the diurnal variations of the elements by the elaborate method in use at Greenwich, which for any one element necessitated the measurement of the hourly ordinates of the curves at 24 points on all but a very few days of the year under consideration. Dr. Wild (British Association Report, 1885, p. 78) advocated the determination of the mean diurnal range from measurements made on the comparatively few days of very small disturbance, and pointed out that the inclusion of disturbed days would affect the form of the curve of diurnal range unless the disturbances occurred indifferently at all hours of the twenty-four. Mr. Whipple had compared the method in use at Greenwich with those of Wild and Sabine for the years 1870, 1871, and 1872 (British Association Report, 1886, p. 71), and came to the conclusion that the difference between the Kew results, as treated by the methods of Wild and Sabine respectively, was less than the difference between the Greenwich and Kew results in either case. The authors decided to make some further comparison of the different methods of reduction, and at Prof. Rücker's request they determined the diurnal variation of the declination at Kew for the years 1883 (a year of maximum sun spots), 1886, and 1887. The mean diurnal range during each year was obtained by Wild's method, the hourly ordinates for about five quiet days in each month being measured. The results obtained were then compared with the corresponding published Greenwich results. The total ranges in each year, according to the two series of observations, are given below :—

Total Ranges.

Year.	Kew.	Greenwich.
1883.	9′·0	8′·5
1886.	7′·6	7′·3
1887.	7′·4	6′·9

The authors point out as noteworthy that the total range at Kew, determined from quiet days only, is greater than that at Greenwich, determined from all days except those of great disturbance. This would appear to indicate that the effect of magnetic storms is to diminish and not to increase the diurnal excursions of the needle. The range of differences of the corresponding mean hourly values is given below :—

——	Range of Differences.	Year.
Greenwich—Kew	−0′·7 to +0′·8	1883
,, ,,	−1′·1 to +0′·7	1886
,, ,,	−1′·1$_4$ to +0′·8	1887

A comparison of this table with the preceding one gives for the percentage differences in the ranges, 16·7, 23·7, and 25·7 respectively. A comparison of the differences of the hourly readings for these three years with those given by Mr. Whipple for the years 1870-72 shows that there is a considerable uniformity in the nature of the differences between the mean hourly readings for Greenwich and Kew respectively. Thus, in each year, the Greenwich mean curve was found to fall below that obtained from the Kew magnetograph at about 7 p.m., and to remain below it until about 4 a.m., after which it remained above the Kew curve until it crossed it about 7 p.m. The minimum ordinate for each curve in each year was found to occur at about 8 a.m., and the maximum ordinate at 1 p.m. The mean value of the declination occurred between 10 a.m. and 11 a.m., and again between 6 p.m. and 7 p.m. Exactly similar features occur in Mr. Whipple's tables for the years 1870-72, and therefore the authors consider that it may fairly be assumed that the general nature of the difference between the Greenwich and Kew mean curves from 1870 to 1887 is the same. The individual readings do not differ from the corresponding mean to an extent greater than 0′·4 ; and they infer that it would be possible, knowing one set of values for any particular year, Greenwich or Kew, to determine the other set, correct to within four-tenths of a minute. As the Kew results are published earlier than the Greenwich ones, the latter might be calculated approximately from the former.

DISCUSSION.

Mr. WHIPPLE said the question as to the manner in which a magnet moves over a few minutes of arc might not seem of much importance, but the fact remained that physicists had always taken great interest in these movements. Before recording instruments were available the numbers had to be obtained by separate experiments. The labour involved in this was considerable, and a single large disturbance might vitiate a whole year's work. Methods of eliminating these disturbances were therefore adopted, amongst which that employed by Sabine might be particularly mentioned. The reason, he thought, why attention had been chiefly directed to declination was because of the relative ease with which such observations could be obtained and reduced. Now that such results had been recorded, it remained to find the causes of the observed variations. These changes did not seem to depend on temperature or on astronomical facts. He said it was very important to obtain magnetic results from different parts of the world ; but comparisons were only possible when all the observations were published on the same plan. He hoped this desideratum would be brought about as the result of the efforts of Professors Rücker and Adams. As soon as this was accomplished the observations on Force would have to be considered. This work would be very laborious, and therefore the aid of volunteers, such as the authors of the Paper just read, would greatly accelerate progress.

Prof. W. G. ADAMS observed that he was glad to see the satisfactory nature of the work which had just been brought before the Society. Usually the mass of figures to be dealt with was so large that the mere reduction was a great undertaking. If, however, the differences between the Greenwich and Wild's methods was not more than $\frac{4}{10}$ths of a minute, the latter might be used with advantage, and might possibly lead to the discovery of the cause of the diurnal variations.

The PRESIDENT (Prof. Ayrton) observed that the movement initiated by Prof. Rücker would be of great value if it resulted in the records of all observatories being published in the same way. It was a great advantage to science that such men as he (Prof. Rücker), who were not permanently attached to any observatory, should take up the subject and suggest improvements ; for the heads of such institutions were usually kept too fully employed in making the necessary reductions, to have time to consider and devise improved methods. In his opinion greater freedom should be granted to the chiefs of such observatories, for it must be borne in mind that the object of the observations was not to produce volumes of figures, but to increase knowledge. Referring to the reduction of observations, he expressed it as his opinion that the voluntary services of senior physical students should be more generally accepted, and to this end he suggested that properly recommended students should be permitted to spend some time in observatories as honorary assistants. This would be a great assistance to the students themselves, and would also enable the reductions to be expedited.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, June 13th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse: "The Physical Foundation of Music." By Prof. SILVANUS P. THOMPSON, D.Sc.

MONDAY, June 16th.

LONDON CHAMBER OF COMMERCE.

2:30 p.m. Electrical Trades Section. Committee Meeting at Botolph House, Eastcheap.

FRIDAY, June 20th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: "The Stretching of Liquids." By Prof. A. W. WORTHINGTON. "The Measurement of Electro-Magnetic Radiation." By C. V. BOYS, A. E. BRISCOE and W. WATSON. "Notes on Secondary Batteries." By Dr. GLADSTONE and W. HIBBERT.

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The Electrician.

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THE INSTITUTION OF ELECTRICAL ENGINEERS' VISIT TO EDINBURGH.

Our New York letter last week contained an interesting account of the doings of the American Institute of Electrical Engineers, which has been holding its meetings away from headquarters somewhat on the lines of our own British Association gatherings. This was not the first time the experiment had been tried on the other side the Atlantic, but the recent meeting seems to have been exceptionally successful, and promoted as it was by the representatives of American electrical industry is of especial interest to our readers. On Tuesday, 20th May, the usual annual meeting was held in New York, when, after the business of electing officers for the ensuing year was completed, the members listened to a Paper on "Electricity in the Navy"; and then, so many of them as could get away, proceeded by night train to Boston, at which place, on the following day, the meeting was continued, and a number of valuable Papers were read and discussed. For the Boston part of the proceedings the Massachusetts

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Institute of Technology opened its doors, affording substantial hospitality in the evening; and on the day following visits were paid to all the more important electrical companies' works in the city and neighbourhood. Altogether the outing was so great a success that invitations to visit other great centres of industry or of scientific learning will probably not long be wanting.

For the purpose of creating local interest in the objects of such societies, as well as for strengthening the community of interests which attach them to the scattered members of the profession they represent, no more useful or sensible plan could be devised than this of extending the meetings beyond the narrow boundaries of the central meeting-house. We are glad, therefore, to notice the experiment of this kind that is about to be tried by the Institution of Electrical Engineers, whose headquarters are, not in New York, but at Westminster, and this in connection with the Electrical Exhibition now being held in the northern capital. The meeting of the London society in Edinburgh has been announced for the 15th, 16th, and 17th of July; and it is very possible that, if this early date is adhered to, the result may be a somewhat meagre attendance. However that may be, the place and the occasion are admirably chosen, and with ordinary care the result ought to be satisfactory as well to the guests as to their entertainers.

Although it has changed its programme to some extent, the Exhibition is still conspicuously an electrical one; and there is a peculiar appropriateness in this state visit of the chief electrical society of Great Britain to an enterprise of that kind. Moreover, Scotland contributes very powerfully to the scientific side of electrical industry, and, with a little encouragement, promises to become a valuable field for its practical application. Metropolitan members of the Institution, if they have much to tell their northern friends, will have also much to hear that will be useful to bring away with them.

The programme of the visit is, of course, not yet made known; but we understand that numerous Papers will be read, more especially such as relate to the electrical features of the Exhibition itself, one by Prof. Ayrton on "Accumulators." The Council will be entertained by the Exhibition Committee; and, as usual at these times, various excursions will be organised for the pleasure and profit of the members. In this connection we naturally recall the liberality of the railway companies, to say nothing of the Exhibition Committee, on the occasion of the opening ceremony. Our American cousins do not hesitate to hire an electrical special train—that is to say, not a train motered by electricity, but carrying passengers belonging to the electrical profession exclusively. It is a sensational notion, and is, of course, designed to create the sensation intended. Our British dignity may not stoop to this kind of advertisement; but it need not be ashamed to approach the railway companies for the purpose of cheapening the journey and extending it to those places of interest with which Scotland so largely abounds. The ordinary express fares are very high, and to a great many members of the Institution are prohibitive. It would contribute not a little to the *prestige* of the gathering if the expense could be so far lessened as to tempt a very large number of the English members to join the party. If they mustered in any considerable force it might pay the railway company even to run an "electrical special" for their benefit.

One other practical suggestion we would venture to offer in connection with the meetings at Edinburgh, namely, that the Council should relax for the occasion their rule against reporters from the technical press. We have mentioned that reunions of this kind always evoke a good deal of local interest, as is right and desirable they should. Representatives of the local press are not merely admitted, but every encouragement is given for the publication of reports of the proceedings from day to day. This is invariably the case during meetings of the British Association; and to some extent, no doubt, the same course will be followed at the Edinburgh meetings of the Institution of Electrical Engineers. Under these circumstances, it would be extremely unfair to deny to the London technical journals what will be freely given to the newspapers of Edinburgh and Glasgow. On occasions like these the Institution must necessarily throw off its reserve in coming before the public at large; and it would be very ill-advised to curtail the facilities for reporting in the only journals that will care to do it full justice.

REVIEWS.

Gas and Petroleum Engines: a Practical Treatise on the Internal Combustion Engine. By William Robinson, M.E. (London: E. and F. N. Spon.)

Engineers who have experience in working steam engines as well as gas engines, no doubt prefer the former to the latter. The steam engine is always ready to start without requiring the waste of a great deal of bodily energy in turning the fly-wheel; it is noiseless, does not smell, easy to put right if anything goes wrong, and, what is most important, it is well understood. The gas engine is a terrible nuisance as a next-door neighbour; it is very often difficult to start, and it often stops without warning; but still all these faults may generally be attributed to the fact that it is not properly understood. The steam engine requires a boiler, and this is very inconvenient for small powers, and at places where space is not abundant; it requires an attendant to be always on the spot to see that the pressure is right, and that there is water enough in the boiler, &c. The gas engine does not require continuous attendance, it only wants a proper-sized meter and feed-pipe and exhaust-pipe. What would electrical engineers have done in many cases if there had been no gas engine?

For these reasons we ought to welcome a book, of which the object is to aid students and practical men in studying this class of engines. The present book is written with this intention, and not only treats on the gas engine, but on the internal combustion engine in general. It begins with the action of the Otto gas engine, which is fully described in detail, with indicator-diagrams, and instructions for starting and working the engine; then follow the Atkinson engine and Powell's Simplex engine, with good explanatory diagrams, and the results of trials. The next chapter deals with petroleum as used in prime motors. This new engine has the advantage of not requiring the presence of gas works, and is well worth the attention of engineers, who will find a good description of the Priestman and Spiel's engines in this book. After explaining the working of Messrs. Yarrow and Co.'s spirit launch, and the "Bailey-Friedrich" petroleum steam motor, there follows a chapter on the history of combustion and caloric engines, which gives interesting and useful information with regard to the development of these engines. In the following chapters the classification of internal combustion engines, mechanism for ignition, admission, and governing, as used in the various modern engines, are all very fully described, with sufficient diagrams.

It is the custom in all text-books dealing with any branch of engineering, to give an account of mass, force and mechanical units as used in practice, the object being to clear away dark clouds from the mind of the reader, who very seldom perfectly understands the foundations upon which mechanics are based. In most text-books this is done in a way which, instead of enlightening the mind of the reader, brings him still further away from the point; and we are sorry to say that this is also the case in some instances in this book in which the engineering units of force and mass are not at all well defined. The

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chapters on heat, including the theory of gases, calorimetry, thermometry, combustion, and fuel, are all very clear and complete, and their presence in a book of this kind is correct. Then comes $\frac{T_2 - T_1}{T_2}$ representing the efficiency of an imaginary engine worked by imaginary gases, and applied to real engines worked by real gases. This subject is certainly treated in a much better way than is usually the case in text-books. The book winds up with a chapter on a series of trials with gas-engines, which are all instructive, and well worth studying.

This book, it may be said, gives the fullest record of the internal combustion engine yet published, and is on the whole clear and instructive; and we can congratulate the author on the result of his labour.

LIFE AND EFFICIENCY OF ARC-LIGHT CARBONS.*

BY LOUIS B. MARKS, M.E.

It was with a view of studying the action of modern carbon pencils that the investigations here to be described were undertaken. The carbons experimented upon were all of American manufacture, and were procured from five companies (A, B, C, D and E). While the greater part of the research was upon the life and efficiency of the pencils, observations were also made in other directions.

The subject will be treated under the following heads:—

1st. Structure of the carbons.
2nd. Life tests.
3rd. Efficiencies.
4th. Candle-power measurements.
5th. Observations of the arc and carbon points.

It is well known that the life and efficiency of a carbon depends upon the system in which the latter is burned. For instance, "the requirement of the low-tension system seems to be a carbon that is hard, well plated, and a good conductor, the latter being the most important." "In the high-tension system, on the contrary, hardness and conductivity seem to be of secondary importance. There is a tendency to 'flame' and burn unsteadily when a hard carbon is used in this system, and a softer one sometimes becomes necessary."† It is interesting to note the methods employed by carbon manufacturers to attain the conditions above mentioned. In one of our largest carbon works "forced" carbons, or those made by "squirting" the plastic material through a die, are manufactured for both high and low tension systems of lighting, to the exclusion of moulded pencils. On the other hand, another company makes no forced carbons, but claims that its moulded pencils are superior for either system. From the classification given below can be seen the types of carbons now upon the market for both systems.

One of the first things that suggested itself was the study of the structure of the various samples submitted. For this purpose thin transverse sections of all the specimens were cut and mounted on glass slides, and a microscopical examination made.

There is a marked difference between the structure of a moulded and a forced carbon. In the high-tension pencil of the brand A, for instance, the structure is a loose one, while the low-tension rod of the same group is marked by a dense homogeneous structure; the size of the grains of carbon in the latter case is very much less than in the former, and, as seen under the magnifying power of the microscope, the particles have a more metalloid lustre. Again, there is probably considerable air-space in Fig. 1.

Life Tests.

If a carbon is burned with a small current its life will be long at a sacrifice of light-giving properties. If, on the other hand, a large current is used, there may be a gain in efficiency at a sacrifice of life. The question arises—what is the proper current to use? Of course, circumstances determine to a large extent the answer, and generally such a current is used as gives a fair mortality at a reasonable efficiency of the carbon. The high-tension carbons submitted for test were designed to be burned at about 10 amperes, and the low tension at about 20. In the life tests a Thomson lamp was used for high-tension runs, current being kept constant at 10 amperes and potential difference at 50 volts. For low-tension carbons the Weston lamp was used. The pencils were accurately weighed before and after the runs, and the life calculated on the assumption that the carbons were homogeneous. Each set of pencils was burned an hour. The results of tests are given in Table 1.

Table I.—*Life Tests.*

Carbon.	Mean diam. Inches.	Resistance. Ohms.	Initial wt. + grms.	Initial wt. - grms.	C. amperes.	P. D. volts.	Loss in wt. + grms.	Loss in wt. - grms.	Life 12in+carbon hours.
A. Moulded high tension*	·502	·199	59·87	25·10	10·	50	5·86	3·59	10·22
A. Forced low tension† ..	·500	·072	64·89	27·16	21·5	30	6 15	4·43	10·55
B. Moulded high tension†	·505	·075	58·17	28·32	10·	50	4·80	2·44	12·12
B. Moulded low tension†	·498	·071	367·80	295·50	22·5	28	166·60	51·50	9·42‡
C. Moulded high tension*	·510	·2165	62·94	29·03	10·	50	6·21	3·03	10·13
C. Moulded low tension†	·515	·0715	594·40	294·50	22·5	28	151·00	41·0	9·83‡
D. Forced low tension† ..	·506	·095	62·46	36·10	21·5	30	6·92	3·08	9·03
D. Forced high or low ten†	·504	·142	60·58	29·78	10·	50	6·65	4·16	9·11
D. Forced high tension*..	·457	·187	47·20	23·53	10·	50	5·46	3 29	8·64
E. Forced low tension* ..	·505	·2207	344·68	244·64	22·5	28	193·18	74·42	7·71‡
E. Moulded high tension*	·533	·202	63·30	30·48	10·	50	6·09	3·04	10·39
E. Forced low tension* ..	·522	·251	59·62	29·81	10·	50	5·91	3·52	10·09

* Naked. † Plated.

‡ These low-tension runs were made with the Weston plant on the University Campus. Ten lamps were run in series. Time of test was 2½ hours in the case of carbons B and E, and 2 hours and 25 minutes in the case of C.

It has been stated that "with carbons of the same *hardness* and length but having different diameters, the larger will undoubtedly outlive the smaller. Of carbons of the same *diameter* and length, but differing in hardness, the harder will outlive the softer."* This statement presupposes that the conductivity of the carbon is directly dependant on the hardness or softness of the pencil. In order to examine more fully the relation between diameter, resistance and mortality of a pencil, six sets of carbons of the brand B, varying in diameter from ½ to 1½ inch, were carefully weighed, their resistances measured by the Wheatstone bridge method, and the pencils burned with a constant current of 10 amperes from a Gramme dynamo, the potential difference at the terminals of the lamp being kept at 50 volts. The diameters and resistances respectively of the upper and lower carbons were in each case practically the same. A mean of 10 micrometer measurements of the diameter was taken as correct. The duration of each run was 60 minutes.

Following are the data:—

Table II.—*Mortality with Different Diameters.*

Carbon.	Mean diameter. Inches.	Resistance. Ohms.	Initial wt. + grms.	Loss wt. + grms.	Life 12in. + carbon hours.
B. Moulded high tension..	·453	·0805	44·70	4·20	10·64
" " ...	·505	·075	58·17	4·80	12·12
" " ...	·618	·0735	94·93	6·96	13·64
" " ...	·739	·0615	132·34	6·19	21·38
" " ...	·986	·061	232·20	8·88	26·15
" " ...	1·195	·059	339·57	10·14	33·49

From the results given in Table II., it appears that the life of a carbon varies *directly* with its *diameter* and *inversely* with its *resistance*. This law holds only for homogeneous carbons of the same manufacture, type and structure, and, as stated before, for constant current and voltage.

Let us take the ½in. (·505in.) and 1in. (·986in.) pencils as standards, and, from the relation above stated, calculate the mortality of the other carbons. Table III., gives a comparison of the actual and the calculated life of the various specimens tested.

Table III.

Carbon.	Mean diameter. Inches.	Standard ½ in. (·505 in.) Calculated life hours.	Standard 1 in. (·986 in.) Calculated life hours.	Actual life hours.
B. Moulded light.....	·453	10·92	9·32	10·64
" "	·618	15·10	13·62	13·64
" "	·739	21·58	19·44	21·38
" "	1·195	36·40	33·04	33·39

Thus it appears that the calculated life throughout the series is larger than the actual when the ½ in. carbon is taken as a standard and smaller when the 1 in. pencil is made the basis of calculation.

The carbons of group B were not perfectly round, a variation of 3% being at times found, between the 10 measurements of the diameter of a pencil. In determining the resistance of the carbon rods, the tips of the latter were copper-plated when necessary and mercurial contacts used. The lamp was adjusted to burn at 50 volts potential difference for each set of pencils. While every pre-

* Read before the General Meeting of the American Institute of Electrical Engineers, Boston, May 21, 1890.

† G. W. Parker: *The Electrician*, March 9, 1888, p. 479.

* G. W. Parker,

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caution was taken to avoid discrepancies, it is clear that from the nature of the substance experimented upon, and the extreme difficulty of maintaining constant conditions, errors are apt to creep into the work. But the results given in Table III. as well as later determinations undoubtedly point to the existence of such a law as has been quoted.

The relation between diameter and life having been investigated, experiments were then made to determine the curve for current and mortality of the pencil, when the voltage is kept constant. For this purpose a number of moulded high-tension carbons of the brand E were used. To secure uniformity in the + and − pencils, a 12-inch stick was broken in half, one portion being used as the upper, the other as the lower carbon. The length of each run was an hour. Current and potential were read every two minutes and the mean taken. Table IV. gives the data from which the curve for current and mortality (Fig. 1) was plotted.

Table IV.—*Life with Different Currents and Constant Potential.*

Carbon.	Diam. mean inches.	Resis. ohms.	Initial wt. + grms.	Initial wt. − grms.	C. amperes.	P. D. volts.	Loss wt. + grms.	Loss wt. − grms.	Life per inch. Carbon burned hours.	Life − / Life +
E. Moulded high ten.	·518	·199	30·20	21·15	6·02	49·3	4·48	2·76	·6723	1·62
,, ,,	,,	,,	25·72	18·38	7·04	49·7	4·87	3·19	·6047	1·54
,, ,,	,,	,,	20·85	15·19	8·01	49·9	5·42	3 25	·5622	1·66
,, ,,	,,	,,	37·56	24·16	8·99	49·9	5·81	3·63	·5450	1·60
,, ,,	,,	,,	31·75	20·53	10·01	49·3	6·16	3·98	·5072	1·52
,, ,,	,,	,,	30·52	21·72	11·00	50·2	6·67	4·18	·4910	1·60
,, ,,	,,	,,	34·30	26·90	12·03	50·3	6·65	4·35	·4637	1·52
,, ,,	,,	,,	37·78	26·33	13·00	50·1	7·26	4·61	·4502	1·57

As will be seen, the range of current was from 6 to 13 amperes. The greatest variation of the mean E.M.F. for the several runs was one volt.

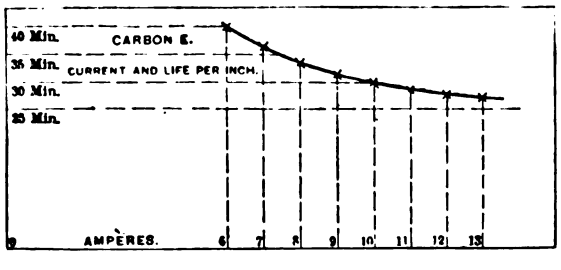

Fig. 1.

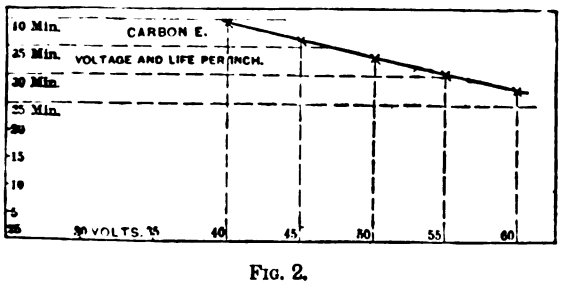

Fig. 2.

Table V.—*Life with Different Potentials and Constant Current.*

Carbon.	Mean diam. Inches. +	Mean diam. Inches. −	Resis. Ohm.	Initial wt. + grms.	Initial wt. − grms.	C. amperes.	P. D. volts.	Loss wt. + grms.	Loss wt. − grms.	Life per inch. Carbon burned hours.	Life − / Life +
E. Moulded high ten.	·513	·513	·199	51·58	48·32	10	40	5·625	2·32	·6425	2·344
,, ,,	·521	·517	·197	37·65	24·16	10	45	5·605	2·87	·6077	1·953
,, ,,	·531	·522	·185	24·86	19·06	10	50	5·83	3·49	·5453	1·693
,, ,,	·531	·522	·185	24·86	19·06	10	55	6·34	4·025	·4903	1·589
,, ,,	·527	·530	·191	23·52	19·34	10	60	6·70	4·41	·4525	1·484

A series of tests was now made with constant-current and varying voltage. The current in this case was maintained at 10 amperes, and the range in tension was from 40 to 60 volts. Carbons of the same type as in the last instance were used. In Table V. are given the figures for these runs, and Fig. 2 shows the curve for voltage and mortality.

In the curves (Figs. 1 and 2) the ordinates represent the life of an inch of carbon in minutes. Reference is made not to the mortality of the + pencil, but to the total amount of carbon burned in the lamp. The last two columns in Table V. have been corrected for diameter and resistance of the pencil, the diameter and resistance respectively of the carbon that was burned at 10 amperes and 45 volts having been taken as a standard, and the life of the other pencils reduced to a common basis from this, according to the law previously stated.

Very little has been published regarding the relative life of the + and − carbons. Those books in which the subject is alluded to, state as a rule that with direct currents the life of the upper carbon is about half that of the lower, provided both have the same length originally. In a recent publication* the general statement is made that "with continuous currents the + wastes twice as fast as the − carbon. With alternating currents the upper wastes 8 per cent. faster than the lower if the carbons are vertical; but at the same rate if horizontal." No experiments were made upon arc-light carbons fed by alternating currents; but an investigation of the relative loss of the + and − pencils with direct currents gave quite interesting results. Table VI. shows that the plus carbon may burn away about as fast as the minus, or may waste more than three and a half times as quickly.

Table VI.—*Relative Life of the Plus and Minus Carbons.*

Carbon.	Initial wt. + grms.	Initial wt. − grms.	C. ampere.	P. D. volts.	Length run. minutes.	Loss wt. + grms.	Loss wt. − grms.	Life 1 in. − / Life 1 in. +
B. Moulded high tension	48·38	25·22	10	50	60	5·28	4·40	1·20
B. ,, low tension.	61·43	31·37	10	50	60	5·14	3·27	1·57
A. ,, high tension	90·57	38·68	10	50	60	5·98	3 20	1·87
10 E. Forced low ten....	344·68	244·64	22½	28	150	193·18	74·42	2·59
10 B. Moulded low ten..	367·80	259·50	22½	28	150	166·60	51·50	3·23
10 C. ,, ,, ,,	594·40	294·50	22½	28	145	151·00	41·00	3·68

Three sets of experiments were undertaken to determine the elements that effect this ratio. 1st, Effect of changing the diameter and resistance of the pencils with constant current and potential. 2nd, Influence of change of current with constant potential. 3rd, Change of potential with constant current.

For determining the influence of diameter and resistance upon the relative life of the plus and minus carbons, a number of moulded high-tension pencils of the brand A were used. The carbons were supposed to have been taken from the same "batch," and were burned with a current of 10 amperes and a potential difference = 50 volts.

Table VII.—*Influence of Diameter and Resistance of the Carbon upon the Relative Life of the Plus and Minus Pencils.*

Carbon.	Mean diam. Inches. +	Mean diam. Inches. −	Resistance. Ohms. +	Resistance. Ohms. −	Initial wt. +	Initial wt. −	Loss wt. +	Loss wt. −	Life 1 in. − / Life 1 in. +	Life 1 in. − / Life 1 in. + corrected.
A. Moulded high ten.	·3964	·4 83	·255	·24	37·91	16·97	4·96	3·04	1·63	1·79
,,	·4567	·4567	·225	·243	48·98	20·26	5·41	3·2	1·65	1·78
,,	·5018	·5153	·199	·207	59·87	25·10	5·86	3·59	1·63	1·74
,,	·5698	·5622	·178	·190	69·83	26·91	6·23	3·61	1·73	1·81
,,	·6311	·6268	·152	·149	90·57	38·68	5·98	3·20	1·87	1·83

Examining Table VII., which gives the results of measurements we note that $\frac{\text{life}-}{\text{life}+}$ appears to become greater with increase of diameter of the carbon. It is probable that the inequality in the diameters of the plus and minus pencils respectively, as well as the difference in the resistances of the two carbons of a set explains, to a large extent the cause of this increase in the ratio. For, assuming that under the conditions maintained, the life of a carbon varies directly with its diameter and inversely with its resistance, the data (Table VII.) indicate that if the diameters and resistances respectively of the plus and minus carbons were the same in each run, the ratio would be practically the same for all sizes of carbons. This is brought out in the last column of the table, which gives the corrected values of $\frac{\text{life}-}{\text{life}+}$.

Reference to the last column of Table IV. will show that a change in the current, other conditions remaining the same, probably has no effect on the ratio $\frac{\text{life}-}{\text{life}+}$. For when a current of 6 amperes was used, the ratio was equal to 1·62; at 7 amperes the ratio dropped to 1·54; it then alternately increased and decreased to 13 amperes. Hence it may be said that if all errors of observation, as well as those due to irregularities in the carbons, could be eliminated, the $\frac{\text{life}-\text{carbon}}{\text{life}+\text{carbon}}$ would be found to be constant.

* Munro and Jamieson's Electrical Rules and Tables 1889.

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The last column of Table V. contains the data for $\frac{\text{life}-}{\text{life}+}$, with different potential differences and constant current. From these calculations it appears that the ratio depends on the potential difference, and that the greater the potential difference the more nearly does the former approach unity. The curve plotted from the figures in Table V. is given in Fig. 3, the abscissæ being volts, and the ordinates representing the ratio of the life of the minus to the life of the plus carbon.

Thus the causes that influence the relative life of pencils of the same diameter lie chiefly in the difference in the resistance of the carbons and the variations of potential difference.

Judging from existing theories of the arc, it was thought that blowing the latter with a magnet during the runs would relatively increase the life of the plus carbon. The experiment was tried, and the reverse was found to take place, *i.e.*, the ratio $\frac{\text{life}-}{\text{life}+}$ increased while the life of the minus pencil was not much affected.

Efficiencies.

Two methods of determining the efficiency of each set of pencils were employed. The first was the method used by Mr. Merritt in obtaining the efficiency of the incandescent lamp,* and subsequently by Mr. Nakano in his work on the efficiency of the arc-lamp.† The second dealt with candle-powers, and will be referred to in the discussion of candle-power measurements.

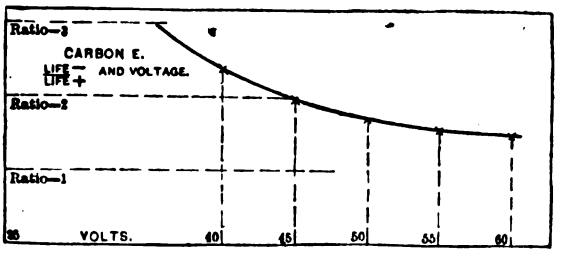

FIG. 3.

It may not be amiss to give here an outline of the first method employed. A Thomson lamp was mounted on a movable frame, and the rays from the burning carbons allowed to fall on the face of a thermo-pile, the latter being in circuit with a sensitive Thomson galvanometer. The deflection of the galvanometer was taken as a measure of the energy of the total radiation which fell upon the face of the pile. A cell containing a solution of alum was then interposed between the light and the pile, and the reduced deflection of the galvanometer noted. On the supposition that the alum cell cut off all the "dark heat," and allowed only the rays of the visible spectrum to reach the face of the thermo-pile, the last measurement would give the true value of the luminous energy emitted by the lamp. But a small percentage of the longer wave-lengths passes through the alum cell, and a large part of the luminous rays is cut off by its intervention. Correction having been made for these factors, the true values of luminous radiation resulted. A mechanism was provided by which measurements could be made at various angles below the horizontal plane without altering the distance between the centre of the arc and the thermo-pile. For the high-tension runs the lamp was fed by a current of 9 amperes, the potential difference between its terminals being kept at 45 volts. For low-tension tests, current = 21½ amperes, and potential difference = 30 volts. Note that the amount of energy expended in the low-tension lamp was $21\frac{1}{2} \times 30 = 645$ watts, while the high tension required but $9 \times 45 = 405$ watts. Although normally the former requires from 520 to 560 watts, unsteadiness of the light when the lamp was run below 21½ amperes made accurate measurements impossible.

Tables VIII. to XV. give the results of efficiency tests. In the column headed (L) are given the corrected values of deflections due to luminous radiation; the values of (T) refer to total radiation and the efficiency or luminous divided by total radiation = $\frac{L}{T}$. These tables furnish the data from which the curves (Figs. 4 to 11) were plotted. The radii show the positions for which measurements were taken, and distances measured along these lines from the origin to the *dotted* curves give the intensity of luminous and total radiation, respectively in each position. It will be seen that the distribution of total radiation differs considerably from that of luminous radiation; hence the efficiency, which is expressed by $\frac{\text{luminous radiation}}{\text{total radiation}}$ depends upon the angle of measurement. The full-line curves (Figs. 4 to 11) represent the efficiencies of the various carbons. In order to obtain the mean or hemispherical efficiency, the areas of the curves of luminous and of total radiation were found by means of the planimeter; now the ratio of the radii of two semi-circles whose areas are respectively equal to those of the curves of luminous and total radiation, is the value of the mean spherical efficiency. This value has been calculated for each set of pencils, and the results are given in Table XVI.; also in Figs. 4 to 11.

Table VIII.

Carbon A. Moulded High Tension.

Angle.	L	T	$\frac{L}{T}$
0°	6·085	110	·0553
10°	8·112	130	·0624
20°	11·49	134	·0858
30°	16·90	146	·1158
40°	23·67	145	·1621
50°	15·55	143	·1087
60°	10·14	125	·0811

Table IX.

Carbon D. Forced High Tension.

Angle.	L	T	$\frac{L}{T}$
0°	4·733	107	·0442
10°	8·133	118	·0688
20°	11·49	129	·0891
30°	14·20	142	·0977
40°	16·91	152	·1112
50°	19·61	156	·1257
60°	8·790	142	·0619

Table X.

Carbon B. Unplated Moulded High Tension.

Angle.	L	T	$\frac{L}{T}$
0°	10·14	114	·0889
10°	13·52	127	·1065
20°	15·55	144	·1080
30°	18·26	157	·1163
40°	22·31	165	·1352
50°	22·31	163	·1352
60°	15·55	156	·0995

Table XI.

Carbon B. Plated Moulded High Tension.

Angle.	L	T	$\frac{L}{T}$
0°	11·49	116	·0991
10°	14·21	128	·1057
20°	15·55	145	·1072
30°	19·60	157	·1248
40°	22·31	164	·1361
50°	18·93	164	·1369
60°	15·55	141	·1103

Table XII.

Carbon E. Moulded High Tension.

Angle.	L	T	$\frac{L}{T}$
0°	2·702	116	·0233
10°	5·405	134	·0403
20°	8·108	146	·0555
30°	13·51	157	·0861
40°	17·57	159	·1105
50°	11·48	145	·0792
60°	7·77	112	·0710

Table XIII.

Carbon E. Forced High Tension.

Angle.	L	T	$\frac{L}{T}$
0°	2·702	118·5	·0228
10°	4·054	131·0	·0310
20°	6·756	158·0	·0428
30°	6·081	—	·0483
40°	10·13	175·0	·0579
50°	14·19	155·0	·0895
60°	11·48	136·0	·0844

Table XIV.

Carbon A. Forced Low Tension.

Angle.	L	T	$\frac{L}{T}$
0°	8·784	162	·0542
10°	12·16	170	·0715
20°	20·27	185	·1095
30°	25·68	190	·1351
40°	25·68	190	·1351
50°	16·89	157	·1080
60°	9·459	130	·0728

Table XV.

Carbon B. Moulded Low Tension.

Angle.	L	T	$\frac{L}{T}$
0°	10·81	190	·0569
10°	17·57	211	·0833
20°	25·68	223	·1151
30°	28·38	223	·1273
40°	17·57	215	·0817
50°	12·33	182	·0678
60°	6·081	135	·0451

Table XVI.—*Efficiency Measurements.*

CARBON.	Diam. Mean inches.	Resistance. Ohms.	C. Amperes.	P. D. Volts.	Horizontal efficiency.	Maximum efficiency.	Hemi-spherical efficiency.	Life 1/in+carbon hours. C. P.D.
A. Moulded high tension	·508	·203	9	45	·0553	·1621	·1171	10·22 (10 -50)
D. Forced high tension	·457	·187	9	45	·0442	·1257	·1001	8·64 (10 -50)
B. Moulded* high tension.....	·453	·224	9	45	·0889	·1352	·1269	9·16 (10 -50)
B. Moulded† high tension.....	·453	0805	9	45	·0991	·1369	·1272	10·64 (20 -50)
E. Moulded high tension	·533	·202	9	45	·0233	·1105	·0896	10·39 (10 -50)
E. Forced high tension	·522	·251	9	45	·0228	·0895	·0776	10·09 (10 -50)
A. Forced low tension	·500	·072	21·5	30	·0542	·1351	·1105	10·55 (21½-30)
B. Moulded low tension.....	·498	·071	21·5	30	·0569	·1273	·0932	9·42 (22½-28)

* Unplated. † Plated.

We notice that the horizontal efficiency is very small compared with the maximum; that relatively high efficiency in a *forced high-tension* carbon is obtained only at the expense of life; that a *moulded* carbon is, generally speaking, superior to a *forced* for high tension, and *vice versâ* for low tension.

* E. G. Merritt: "Some Determinations of the Energy of the Light from Incandescent Lamps." *Amer. Jour. Science*, Vol. XXXVII., p. 167.

† H. Nakano: "Efficiency of the Arc-Lamp." Transactions Amer. Inst. Elec. Eng. Vol. VI., p. 308.

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In the case of the high-tension carbon B and D the diameters are smaller than those of the other pencils; hence we are to expect a relatively higher efficiency, since, as was shown last year, the efficiency varies inversely as the diameter.*

of *combustion* in both cases is the same, while the *disintegration* caused by the passage of the current is greater in the case of the unplated carbon.

(To be continued.)

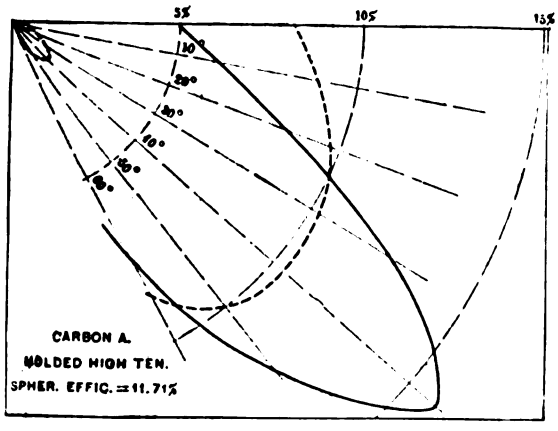

FIG. 4

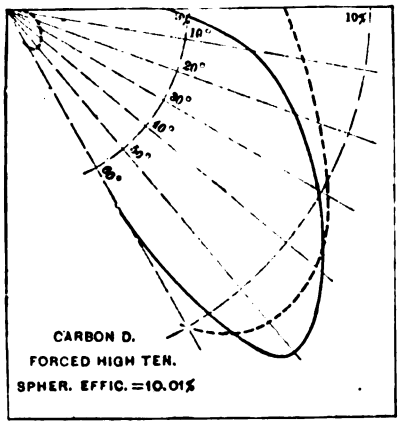

FIG. 5.

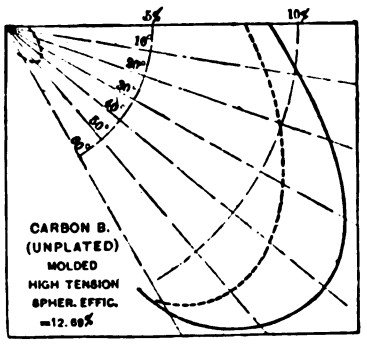

FIG. 6

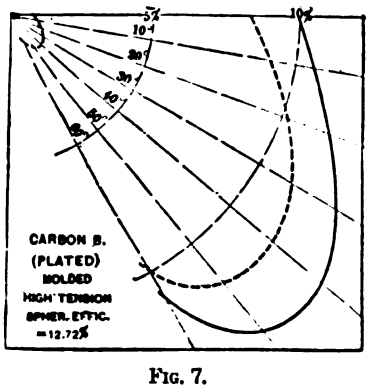

FIG. 7.

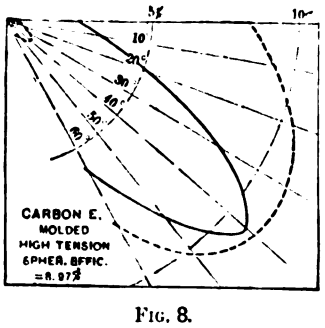

FIG. 8.

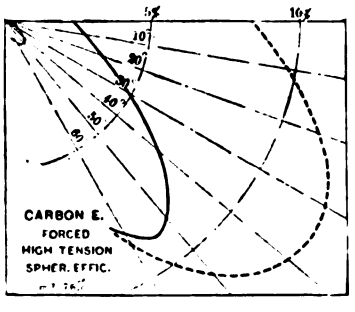

FIG. 9.

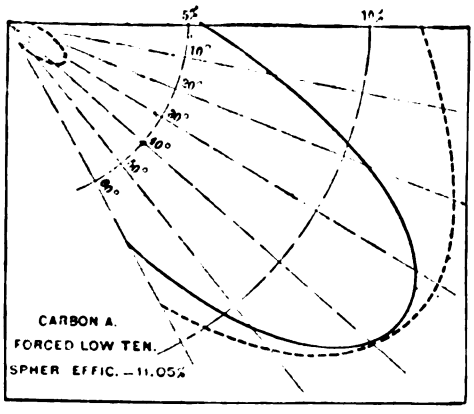

FIG. 10]

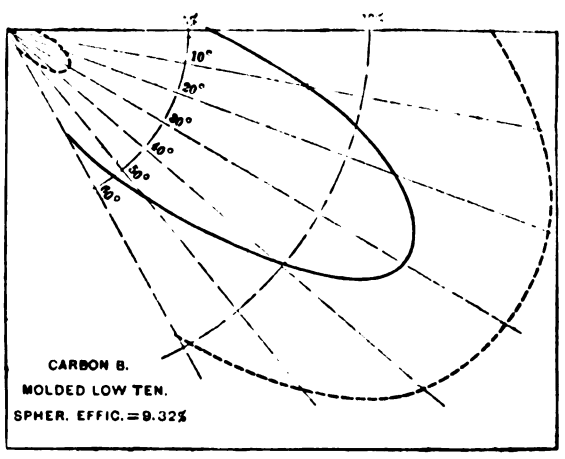

FIG. 11.

A point of interest brought out by these tests (Tables X. and XI. and Figs. 6 and 7) is the fact that while the life of a copper-plated carbon is greater than that of an unplated carbon of the same diameter and type, the mean spherical efficiency appears to be the same for both. Two sets of pencils of the brand B, the one unplated and the other plated, were burned to ascertain this relation. The results show that the horizontal and the maximum efficiency of the copper-plated carbons were a little greater than those of the uncoated pencils respectively, and the mean spherical efficiency in the latter case was very slightly less than in the former. As can be seen from Table XVI., the life of the "positive" plated pencil (12" long) was 10·64 hours, while that of the naked carbon was 9·16 hours, the current and potential difference having been the same for both cases. No positive explanation of this phenomenon has yet been given, but it appears that the actual amount

* H. Nakano.

Magnetic Data of the Sprague Street-Car Motor.—In a Paper read at the recent Boston meeting of the American Institute of Electrical Engineers the following values were found by Mr. H. F. Parshall for the magnetic leakage in the Sprague motor:—

	Wrought-iron pole pieces.	Cast-iron pole pieces.
$\frac{\text{Lines magnet}}{\text{Lines armature}}$	1·45	1·52
$\frac{\text{Lines middle of yoke}}{\text{Lines armature}}$	1·27	1·33
$\frac{\text{Lines middle pole piece}}{\text{Lines armature}}$	0·666	0·7

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THE TREATMENT, REGULATION, AND CONTROL OF ELECTRIC SUPPLY BY THE LEGISLATURE AND THE BOARD OF TRADE.*

BY MAJOR P. CARDEW, R.E.

(Concluded from page 119.)

Safety Regulations.

These were embodied in the old Orders, and were in great detail, such points as the distance apart of terminals, and the maximum current to be taken from any pair of terminals, being specified. The pressure on distributing mains and service lines was not to exceed 200 volts continuous or 100 alternating; and no portion of an electric line placed above ground, and not enclosed, was to be at a pressure from earth exceeding 200 volts.

The St. Austell Licence of 1885 is, I think, the first licence or Order in which separate regulations have been issued; and the same form has been used in the Kensington and Knightsbridge Order of 1889 and the St. James's Licence of 1888, and nearly the same form in the Chelsea Order of 1886. These are more general in character. The limit of low pressure has been raised to 300 volts continuous, while alternating currents are not to be used except with the approval of the Board of Trade, and under such further regulations as may be considered necessary.

A very important innovation has also been introduced in these regulations, providing that the undertakers shall cut off any consumer upon whose premises they find that a leakage exists having resistance to earth of less than 5,000 ohms. This is to some extent a departure from the policy of the Board of Trade to leave the regulation of the circuits on private premises to the insurance companies; but, unfortunately, electricity does not conform to these arbitrary distinctions, and a bad leak on a consumer's premises is just as much a source of danger and difficulty as one on the main outside—in the case of direct supply systems, at any rate.

The general regulations for overhead wires, made under Section 4 of the Act of 1888, are pretty generally known at the present time, and I need not dwell upon them. As you are aware, they were thoroughly revised by your Council, who have also given their powerful assistance to the Board of Trade in the matter of some new proposed general regulations for undertakers of electrical supply, which, however, are still under discussion. The principal features of the new draft regulations are—(1). The division of the various systems of supply into three classes, viz., low pressure, high pressure, and extra high pressure; low pressure to extend to 300 volts continuous or 150 alternating; high pressure, from above this to 3,000 volts, either continuous or alternating—that is, to as high a pressure as we have had practical experience of in distribution systems; extra high pressure, above 3,000 volts. (2). A general provision that where high-pressure conductors or apparatus are exposed in such positions as to be possibly touched by persons, or brought into contact with low-pressure conductors, they shall be entirely enclosed in strong metal casing efficiently connected to earth.

Supply Regulations.

These have been subjected to less alteration than the Safety Regulations. The variation of standard pressure permitted has been reduced, and in the new draft it is proposed, as already stated, to introduce the idea of a pressure to be declared at the consumer's terminals, which is not to vary more than 4 per cent., and the variation of which may be tested for the consumer on his application by the electric inspector. It is also proposed to take advantage of the powers of the transformer system, and provide that the consumer supplied from a transformer on his premises shall have the choice of two pressures given him, one about half the other.

No doubt many of the regulations that have been made are open to criticism: but I would point out that they are in every case the result of very careful consideration, and that observations on them from many different points of view have been submitted, and given, as far as possible, their due weight. It is not unlikely, therefore, that a criticism, even from a high electrical authority, may be unjust and erroneous, from the critic not being acquainted with all the circumstances and conditions which have guided the Board of Trade; and it should also be borne in mind that the Board are empowered to alter any regulations issued by them, or to repeal them and issue fresh ones, should the progress of electrical discovery and further experience make such a course desirable. And whatever imperfection may become apparent in these regulations, I can confidently affirm—and I feel sure that this proposition will receive the support of those among you who have experience of its methods of procedure—that the Board of Trade has been guided solely by the desire to do the duty imposed upon it by Parliament, and to serve the best interests of producers and consumers alike.

The Standardising Laboratory.

And now, I should like to say a few words about the standardising laboratory. You are probably aware that the Board of Trade have, in deference to the wishes of the large body now interested in practical applications of electricity, as expressed by a powerful deputation to the President last year, undertaken to provide something in the nature of a testing establishment for instruments intended for the measurement of electrical quantities, analogous to the Standards Department of the Board of Trade for weights and measures of the more gross and material quantities. They have also taken powers under the Weights and Measures Act of last Session to undertake such testing and verification, and to charge fees for it; so that these verifications, whatever their scientific value, will possess a legal value. A general scheme for the scope and working of this laboratory was drawn up very carefully last year by a committee of your Institution, in connection with which I should like to mention especially the hard work done by Dr. Fleming, in a cause which he has given abundant proof that he has at heart. The general idea embodied in this, in which I personally entirely concurred, is that the thing should grow from small beginnings. This, I think, is the English way, and I need only point to the present position of our own Institution as an example of its success. Our more impressionable neighbours on the other side of the Channel like to start these things in a different way. They must have something grand and striking, and of course there is much to be said for this view, if you have the means to carry it out; but it sometimes leads to, as it were, setting up a steam hammer to crack nuts. No doubt the steam hammer can do it very well, but a pair of nut-crackers is cheaper. Now I can promise that there will be nothing grandiose about our laboratory—we are starting with a very ordinary pair of nut-crackers. It is hardly necessary to observe that the small beginnings idea was the part of the scheme most to the taste of the Treasury; in fact, to use an electrical metaphor, my Lords would have liked our electrical particle to have acquired its potential of doing work by starting in the legitimate way at an infinite distance from the charged body (the national purse), and to have been a long time on the road too. However, let us not forget that if we are electricians we are also taxpayers!

Now, what we hope to do in this laboratory is, first of all, to get the true values of the electrical units, within a very small possible percentage of error. We are not tied to the so-called legal units, which I may remark have no legal value in England; but, with the assistance of Lord Rayleigh and the Standardising Committee of the British Association, we hope to get even nearer the truth than was arrived at with this set of units. Secondly, having got there, we hope to keep there by well-devised checks and frequent reference to the fundamental measurement. This, as we are at present advised, will be the measurement of current by the quantity of silver deposited from solution in a determined time. Thirdly, as soon as we are satisfied that sufficient accuracy and permanence has been arrived at with our instruments and methods, we shall be ready to receive instruments, either for simple verification in the case of ordinary commercial instruments, at a small charge for each reading, or for thorough testing and certification in the case of instruments submitted as sub-standards. The rules and charges have not yet been drawn up, but it is probable that instruments will be required to be marked with a clear and intelligible scale—whether of degrees or volts or amperes, &c., is quite immaterial; the extreme range of the instrument must be given approximately, and whether it is intended for alternating or continuous currents or pressure, or for both. The reading given by the instrument on its own scale for each current or pressure asked for will be taken, probably, in all cases both with increasing and with decreasing readings. No extreme accuracy will be guaranteed for these readings, but it is hoped not to exceed an error of $\frac{1}{4}$ per cent. from the true value. Of course, in the case of ordinary commercial instruments, we should give no sort of guarantee that the instrument will remain constant for any time, or under different conditions. Sub-standards will be subjected to long and rigorous testing, including the determination of their variation under different temperature and the permanence of their constants. I am afraid, however, that in most cases there will be some difficulty in giving any guarantee of the constancy of an instrument after it has passed out of our hands.

The power for laboratory purposes will be supplied from two batteries of accumulators—one of four very large cells simply to give steady continuous currents up to 2,000 amperes; the other, consisting at first of 100 smaller cells, will be used directly for continuous pressures up to 200 volts, and also to run the machinery. The machinery referred to is two pairs of dynamos, one of each pair being energised by the cells as a motor and driving the one connected to it as a generator. One of these

* Paper read at the Institution of Electrical Engineers, on May 15, 1890.

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generators will be an alternate-current machine, and the other a high-pressure continuous-current machine. In connection with the alternate-current machine we shall have a set of transformers. In this way we hope to get currents practically as steady as if taken direct from the accumulators, and in the case of alternating currents and pressures any frequency within the limits of practice. The limits we propose to work up to at first are—

Continuous current ...	...	...	2,000 amperes ;
,, pressure ...	...	...	2,000 volts ;
Alternating current ...	...	...	500 amperes ;
,, pressure ...	...	...	2,000 volts.

The building and alterations necessitated are now nearing completion, and we hope to have the laboratory in working order in about two months' time.

LEGAL INTELLIGENCE.

Crompton and Co. (Limited) v. the Elieson Electric Company (Limited).

In the Queen's Bench Division, on Friday, Mr. Baron Huddleston and a special jury resumed the hearing of this case.

Mr. THOMAS BRICE GOWER, secretary of the Elieson Electric Company, stated that the works at Romford-road, Ilford, were erected expressly for the supply of electric engines to the North Metropolitan Tramway Company, and that in consequence of the arrangement between the defendants and the tramway company falling through, the works had been rendered useless, and the defendants had sustained a heavy loss.

Cross-examined by Mr. MOULTON: In the agreement between the defendants and the tramway company the latter had to keep the whole of the tram lines in proper repair. The siding where the wheels of the engines were broken through the defective connection was laid down by the permission of the tramway company by one of that company's usual contractors. The contractors who laid down the siding were competent persons for laying lines for horse traction, but he did not know that they had ever had any experience with regard to mechanical traction. He denied that the defendants had a breakdown with their armatures. The breakdown in 1887 was under the old company, and not the present one. One of the acts of negligence he alleged against plaintiffs was that they sent out an engine with a washer so deep that the teeth of the rack of the engine did not bottom properly, and consequently they got broken. He did not admit that this washer was the same as had been used by the defendants for months, but he would not swear that it was not. He also alleged that it was an act of negligence on the part of the plaintiffs to use the starting switch for reversing the engine. He denied that in the defendants' line a large driving switch was in common use for reversing.

Mr. LESTER, a member of the defendant company, gave evidence with reference to the agreements made by the defendants with the North Metropolitan Tramway Company and the plaintiffs respectively.

Mr. BOUSFIELD, mechanical engineer, said he had had a large experience in the business, and had examined the machinery of the defendants' engines. He considered the defendants' system a good one. The breaking of the engine wheels was due to the points being wrongly constructed. With regard to the breaking of the teeth of the rack, the teeth, instead of going home, only touched on the tips, and this was due to the motor being raised too high by the washer.

Prof. SILVANUS THOMPSON gave evidence to the effect that he had examined the defendants' system, and that in his judgment it ought to work well for the running of electric engines. With regard to the breaking of the teeth of the engine rack, he attributed that to two causes—the insufficient setting of the guard, and the motor being improperly started with too strong a current.

Mr. ASHER said the engines in question were constructed for the defendants under his superintendence, and he firmly believed the system was a good one in all its details. He agreed in substance with what the two previous witnesses had stated.

This concluded the defendants' case.

Mr. MOULTON, in opening the case for the plaintiffs, said the little mishaps and accidents that had occurred to the defendants' engines were such as generally overtook the pioneers of any new form of locomotion. The plaintiffs merely acted as managers of the Plashet works for the defendants, and none of the defendants' contracted arrangements were communicated to the plaintiffs. Messrs. Crompton and Co. were electrical engineers of very wide experience and very high standing in their profession, and they occupied towards the defendants the position of managers, and if they were going to say that managers were responsible for all carelessness and negligence on the part of workmen under them, then the position of managers would become intolerable. Everyone of the men who worked for the plaintiffs had previously been in the employ of the defendants, and had been in the habit of performing the work of charging the accumulators with electricity to the extent of twenty times a day. Therefore they must be considered to be experienced and reliable workmen, and the plaintiffs, as managers, were entitled to rely upon them doing their work in a competent manner. They might just as well say that the manager of a large tramway company was responsible if one of the horses of the company did not get its feed, as to say that the plaintiffs were responsible for every act of the workmen under them. The accidents which had occurred were such as were inevitable in starting an invention of this kind. With regard to the siding, the usual course in laying down points was to run an engine up and down the line to see whether it cleared the points properly, and when the contractors were fixing the points at the works by the order of the defendants the plaintiffs placed at their disposal an engine for that purpose. Therefore, it could not be said that the plaintiffs would be guilty of any negligence. As to the alleged insufficient storage of electricity, the learned counsel said the plaintiffs took over the defendants' men, who had had experience in this kind of work, and that therefore the plaintiffs were justified in relying upon those men doing the work properly.

The case was then adjourned till Saturday.

SATURDAY, June 7th.

On the case being resumed on Saturday,

Mr. R. E. B. CROMPTON, of the plaintiff company, was called, and stated that during the negotiations with the defendants there was no question whatever with regard to his firm taking over the risk of the defendants' business. The written agreement which had been put in fairly represented the conversation which passed at the time when he attended the defendant company's Board meeting. It was the custom of the plaintiffs to send the defendants weekly accounts and the wages sheets, and the defendants sent back cheques for the amounts. The plaintiffs engaged some men beyond those already in the employment of the defendants. The stopping of one of the engines did not occur in consequence of the accumulator being insufficiently charged. He believed the accident occurred through the breaking of a connection. The small-power switch was a dangerous addition to an engine, and was unnecessary. He would work by switching on and off with the main starting switch. The contract between the defendants and the North Metropolitan Tramway Company was not made known to plaintiffs. It would cost about 30s. to repair the teeth of the rack.

Cross-examined by Mr. FINLAY: Personally he gave very little attention to the Plashet Hall works. The actual superintendence was left to Mr. Chamen. He held that the breakdown took place in consequence of the breakage of a connection. The plaintiffs had evidence of that, and also that the accumulator was properly charged.

Mr. WILLIAM CHAMEN stated that he had been with the plaintiffs for nine years, and that for four or five years he had acted as manager of the installation department. He had had great experience in electrical matters. Seventeen men at the works were employed by him; but the majority of them had previously been employed by the defendants. So far as he knew, they were competent to perform the work he allotted to them. On Saturday, September 8th, running was recommenced, and the accumulators were charged by his directions. Mr. Howes, the foreman, had the superintendence of the operation, and proper appliances were provided and used. The mishap to one of the engines did not arise from the accumulator being insufficiently charged, but from the breakage of a connection. When the siding at the works was being laid he placed an engine at the disposal of the contractors on more than one occasion, in order that the points might be tested. The engine was run forwards and backwards over the points. He remembered the breaking of the wheels of one of the engines. He was close by when the accident occurred, and a broken piece of the wheel was found on the road. The washer was never touched. When the engines came under the supervision of the plaintiffs the small-power switch was attached to all of them. He made inquiries of Mr. Howes, the foreman, and of the drivers, respecting them, and they all complained that those switches were continually getting out of order. He satisfied himself that it was easy to reverse with the main switch, and that the small-power switch was unnecessary.

Cross-examined by Mr. FINLAY: With regard to the breakage of the teeth of the rack he thought that the first breakage was probably due to slipping. If when the first tooth had broken he had removed the whole of the remaining teeth the accident would have been prevented. He knew of the existence of the washer, but he was at the works to see that the engines were in a proper state to work and not to alter the gear. He heard that the washer was reduced after the accident, but he had no personal knowledge of it. The motion was gentler with the large-power switch. He took charge of the engines at Stratford before they were moved to Plashet Hall.

Prof. ALEXANDER KENNEDY, F.R.S., had been down to Plashet Hall works twice and seen the defendants' engines. He made such experiments as he could, and was satisfied that there was sufficient spring in the upper part of the engine frame to allow the pinion teeth to move in the rack up or down a little less than a quarter of an inch. He believed that the motion could take place through the jolting on the road. It would be prudent to leave a space between the end of the teeth and the bottom of the space on the rack; that would be a matter determined by experience in working. If an engine had been working well for six months he would certainly not take the responsibility of altering it. With regard to the relative advantages and disadvantages of starting an engine with the ordinary driving switch, or having a small-power switch, he thought on theoretical grounds there was no doubt that the small-power switch would not be as good as the main switch used in the manner in which he saw it used at the works. There was no difficulty in using it in that way. If he had the management of such engine he had no doubt whatever that he should start with the main switch.

Cross-examined by Mr. FINLAY: In order to ascertain that the upper part of the engine would dip to the extent he had mentioned, he lifted up the upper end by means of a bar. He did not ascertain by actual experiment that any jolting on the road would cause a dip to such an extent; in fact, he had not seen one of the engines running on the road.

The further hearing was adjourned till Monday.

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MONDAY, June 9th.

On the resumption of this case, Mr. A. J. HOWES said that in the early part of 1888 he was in the employ of the defendants, being foreman under Mr. Gower. When the Plashet Hall works were started under the management of the plaintiffs he was transferred to those works, and he continued to work under the plaintiffs until September, 1888. At the Plashet Hall works he took his directions from the plaintiffs and sometimes from Mr. Gower. Witness looked after the charging of the accumulators. He was accustomed to do that kind of work when he was working under the defendants earlier in the year.

His LORDSHIP: What do you suppose was the cause of the failure of the accumulators?

WITNESS: The accumulators were properly charged. I was at Stratford when the engine arrived, and I attribute the accident to the breaking of a connection through the vibration of the engine while going along the road. Witness said he was present when one pair of wheels broke at the points. From what he saw he concluded that the points had broken the wheels. He remembered a new set of teeth being placed on the rack of one of the engines by Mr. Chamen's direction.

Cross-examined by Mr. FINLAY: Prior to the engines stopping running in March, 1888, he had been in the employ of the defendants a fortnight or longer. That was the extent of his knowledge of the defendants' system.

Two drivers were then called, and gave evidence that the main switch was commonly used because the small-power switch was continually getting out of order.

This concluded the evidence for the plaintiffs.

Mr. FINLAY said he should contend on behalf of the defendants that if an expert was employed for the purpose of putting certain machinery in order, or to conduct a particular experiment, and it was well known to him that a failure of the work or experiment would result in loss to his employer, the employer was entitled to recover damages.

His LORDSHIP said he should hold that that was not so.

Mr. GRAHAM, in addressing the jury on behalf of the plaintiffs, contended that his clients had been guilty of no negligence, and that even if they had, the defendants were only entitled to recover the trumpery sum of £9. 1⁰s. He also denied that at the time of the arrangement between the plaintiffs and the defendants the defendants had any contract with the Metropolitan Tramway Company.

Mr. FINLAY, on behalf of the defendants, said the plaintiffs had clearly been guilty of negligence in the supervision and management of the defendants' works, that the mishaps were the direct result of that negligence, and that consequently they (the plaintiffs) were liable to pay damages.

His LORDSHIP, in summing up the whole case, said the defendants had admitted the plaintiffs' claim to the extent of £384, and therefore the plaintiffs were entitled to a verdict for that amount. The next question was whether the defendants were entitled to recover anything from the plaintiffs; and to decide that question they must first ascertain what was the exact position in which the plaintiffs stood to the defendants—whether they were merely managers, or whether they were contractors. The learned Judge then proceeded to deal with the agreements between the plaintiffs and the defendants, and the evidence which had been given both in support and against the alleged acts of negligence.

The Jury retired, and after a short consultation they returned into Court with a verdict for the plaintiffs in the claim for £384, and for the defendants on the counterclaim for £184. They found that the plaintiffs were contracting parties, that they were guilty of negligence as regarded the accumulators and rack teeth, but not as regarded the wheels and the points of the siding.

His LORDSHIP gave judgment accordingly, and certified for the special jury.

Mr. MOULTON asked that the defendants might be deprived of their costs. While they claimed £10,000, they had recovered only £184.

His LORDSHIP said it was a sound rule that costs should follow the event, and therefore he declined to deprive the defendants of their costs.

TELEGRAPHIC RATES TO AUSTRALIA.

The following letters, relating to the subject of the reduction of the Australian Cable rates, may prove of interest. The first of these letters, which has not before been published, was addressed to the Agents-General of the Australian Colonies by Sir John Pender on the 25th ult.; and the remainder have appeared in *The Times*; the second and third on the 7th inst., the fourth on the 9th inst., and the last in yesterday's issue.

GENTLEMEN: Since our conference yesterday, I have had a meeting with our allied companies, which leads me to believe that we shall be able to eventually come to an understanding with them, more particularly the Eastern and Indo-European Telegraph Companies. The Persian Gulf department may be more difficult to deal with; but as that administration is practically the Indian Government, probably the influence of the Colonies upon India may be effectual in bringing them also into the proposed arrangement. However, there is no time to be lost; and it is very important, while the Conferences are sitting in Adelaide and Paris, that the principle should be definitely settled.

Therefore, believing that the present difficulties will be overcome, I am prepared to accept the 4s. tariff, although it involves a very large additional loss in the first instance. Still, I believe that the lower rate will probably more quickly recoup the loss than the higher tariff; and as the 4s. rate was embodied in our first proposition to the Colonial Governments, and has evidently made an impression on the minds of the Colonists, we are the more anxious that whatever arrangement is made should command the approval and support of all parties concerned.

The term for testing the effect of a cheap tariff will be for one year certain; but if at the end of that period, as I have stated in my telegram to Adelaide, our loss is not a serious one, we shall have no objection to extend the term to three years; at the end of which time, if it is found that the loss is likely to be recouped within a reasonable period, the arrangement shall be continued for the remainder of the term of our subsidy agreement with the Colonies.

It is understood that the reduced tariffs come into force on and from the 1st of January next. This will give ample time for the financial arrangements with the different Colonial Governments and Her Majesty's Government to be made; but these, of course, rest entirely with the Governments themselves.

I am, Gentlemen, your obedient servant,
JOHN PENDER, Chairman
The Eastern Extension, Australasia, and China Telegraph Company, London, E.C., May 25.

P.S. I enclose a copy of the telegram I am to-day forwarding to our agent at Adelaide, giving the Company's decision in regard to Mr. Derham's resolution.

The Agents-General of the Australasian Colonies.

[Copy of Telegram.]

25th May, 1890.

Director-General Extension Company, to Director, Adelaide.

After further conferences with Agents General, and rather than lose present favourable opportunity of settling matters, Chairman willing to waive conditions specified in telegram to Todd, 23rd, and will agree to a

4s. 0d. tariff for ordinary,
3s. 6d. „ Government, and
1s. 10d. „ Press messages.

Governments should remember that the half rate is only given over the extension lines in consideration of the subsidy which the Extension Company receives from the Colonies, and therefore impossible to reduce Government messages below 3s. 6d. With regard to duration of experiment, Chairman must adhere to previous proposal—namely, if at end of first year no serious loss involved, Company will continue experiment for another two years; but this must remain at Company's option. Should loss be nearly recouped at end of three years, Company will extend arrangement for remainder of subsidy term. Above figures are based on South Australia accepting transit rate of fivepence.

SIR: My attention having been drawn to the foot-note to an article appearing in the current number of the *Nineteenth Century*, purporting to have been written by Mr. Henniker Heaton, M.P., and in which the writer says that, "Nevertheless, I have been able to take effective outside action, which has resulted in wringing from these hard-fisted associations a reduction of the rate to Australia to 5s. per word," I have no hesitation in saying that the statement is absolutely without foundation, as all the other parties to the arrangement can readily testify.

The 4s. rate now provisionally arranged between the companies and the Adelaide Postal and Telegraph Conference is the outcome of negotiations conducted between myself and the several Agents-General of the Australasian Colonies prior to, and entirely independent of, the Paris Telegraph Conference, to which it has not so far been submitted, it being quite beyond the control of that body.

I am, Sir, your obedient servant,
JOHN PENDER, Chairman
The Eastern Extension, Australasia, and China Telegraph Company, London, E.C., June 5.

SIR: During the past five years I have in Parliament, in the Press, and on public platforms, and as delegate of an Australian Government at the Berlin Conference, denounced the monopoly enjoyed by Sir John Pender, and the monstrous charges made by him for cable messages to Australia and India. In a letter to *The Times* on May 3rd I pointed out the enormous profits realised, and urged a reduction. On Saturday, May 10th, I telegraphed to Australia that a reduction of telegraph rates from 9s. 4d. to 5s. per word would take place, and a telegram appeared in the Australian newspapers to the same effect on Monday morning (if not delayed in transit), in which telegram my name appears. On Monday afternoon, May 12, Sir John Pender met the Agents-General, and on Tuesday, May 13th, Sir John Pender wrote agreeing to reduce his own charges to Australia from 9s. 4d. to 5s. per word, under certain conditions. Sir John will have no difficulty in understanding how I managed to force him to reduce the rates, if he will make inquiry; but I think I have proved that before his meeting the Agents-General in conference I had made up my mind to force him to reduce the rates, and that I knew I should succeed. After the final settlement I pledge myself to produce conclusive evidence from independent witnesses of the truth of these statements. But I do not wish a personal dispute between Sir John Pender and myself to cause a rupture in the arrangements, particularly as the question is now under review at the Colonial Office.—Your obedient servant, J. HENNIKER HEATON.

SIR: When Mr. Henniker Heaton attempts to appropriate the credit of having broken down the monopoly of telegraphic communication to Australasia, and to have effected by his own unassisted efforts a widespread reform in one of the most important departments of modern civilisation, it is time that the absurdity of any such pretensions on his part should be

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exposed. Sir John Pender's letter, which you publish this morning, shows conclusively that Mr. Henniker Heaton has not been in the remotest degree instrumental in bringing about a reduction in the cable rates to Australasia. If any further evidence be required, it will be found in Mr. Henniker Heaton's own letter on the subject, which also appears in your issue of to-day, in which he alludes to the proposed rate as being 5s. per word, instead of 4s., as stated by Sir John Pender, thereby exposing his ignorance of the subject upon which he is writing.

It may be of interest to your readers, now that Mr. Henniker Heaton's claims have been disposed of, to know the means by which the reduction from about 9s. 4d. per word to 4s. in the cable rates to Australasia has been effected.

In 1886 the Pacific Telegraph Company was formed by Mr. Randolph Want, of Sydney, and myself, having for its object the laying of a cable from Vancouver Island to Australia. Among the signatories to the articles are Sir Donald Smith, Mr. Sandford Fleming, Sir Samuel Wilson, Sir James Corry, Sir William Clarke, Sir Daniel Cooper, and the late Lord Milltown. When the Colonial Conference assembled in London in 1887 a formal proposal was put forward by this Company to the several Colonial Governments, offering to lay a cable from Canada to Australia, and to reduce the tariff to a maximum of 4s. per word from this country to Australasia, in consideration of a certain subsidy for 25 years.

It was, of course, necessary that such a proposal should be met by the Eastern Extension Company, who accordingly followed suit by offering to reduce their rates, under certain conditions, to 4s. per word.

The proposal of the Pacific Telegraph Company is still under the consideration of the Canadian and Australasian Governments. Last year the Canadian Government invited the Governments of the Australian Colonies to meet in a Conference at Sydney to discuss, among other matters, the question of the Pacific Telegraph Company's proposal. The Conference has been postponed, owing to the question of the inter-colonial federation of the Australasian Colonies having for the time being superseded all other considerations. In the meantime the survey of the proposed cable route has been practically completed. Every day that passes exposes more clearly the ineradicable defects in the existing system of cable communication to the East, and everything points to the certainty that such a hiatus in the world's telegraphic system as is now represented by the Pacific Ocean is quite incompatible with the requirements of modern civilisation, and especially with the rapid expansion of Canada and Australasia. That the Pacific cable will before long be laid is a certainty to which no one is more alive than Sir John Pender, and it is to the considerations set forth above, and to no other, that his being forced to agree to a reduction of over 50 per cent. in his Australian rates may safely be ascribed.—Yours, &c.,

34, Clement's-lane, June 7th. HAROLD FINCH-HATTON.

SIR: I can picture the amazement which those aquainted with the genesis of the Pacific Telegraph Company must have experienced on reading the statements of our secretary in that association, Mr. Finch-Hatton, in his letter to *The Times* this morning.

He says that to the formation of the Pacific Cable Company, and not to me, the credit is due for forcing Sir John Pender to agree to the reduction in Australian cable rates. The letter also contains the following remarkable paragraph:—

"In 1886 the Pacific Telegraph Company was formed by Mr. Randolph Want, of Sydney, and myself (Mr. Harold Finch-Hatton), having for its object the laying of a cable from Vancouver Island to Australia. Among the signatories to the articles are Sir Donald Smith, Mr. Sandford Fleming, Sir Samuel Wilson, Sir James Corry, Sir William Clarke, Sir Daniel Cooper, and the late Lord Milltown."

Incredible as it may appear, the articles of association contain my name as one of the original founders, and it was wilfully suppressed by Mr. Finch-Hatton in his letter to you. My solicitors even drew up the articles. I send you the document for inspection. As secretary to the Company, Mr. Finch-Hatton sends me periodically a summons to attend the general meetings.

In 1882 I was looking about to find a means of breaking up the monopoly enjoyed by Sir John Pender. Captain Audley Coote, M.L.C., of Tasmania, suggested the Pacific cable, and at his instance I formed in 1884-5 a Company in London, consisting of Lord Milltown, Sir James Corry, M.P., the Right Hon. H. Cecil Raikes, M.P., Mr. H. G. Reid, M.P., Lord Radnor, and myself. These names, with that of Mr. George Coote, as representing Captain Audley Coote, were placed before Messrs. Wilson, Bristowe, and Carpmael, the eminent solicitors, who drew up the Articles of Association. Mr. Raikes was appointed Postmaster-General, and retired before a meeting was held. We then found that another company had started with a similar object. We amalgamated our forces. If the reduction of rates is due to the existence of the Pacific Telegraph Company, I am still, on Mr. Finch-Hatton's own showing, more responsible than anybody for "the credit of having broken down the monopoly" in question.

Just one more exposure of Mr. Finch-Hatton's want of candour, and I have done. He writes:—

"If any further evidence be required it will be found in Mr. Henniker Heaton's own letter on the subject, which also appears in your issue of to-day, in which he alludes to the proposed rate as being 5s. per word, instead of 4s., as stated by Sir John Pender, thereby exposing his ignorance of the subject upon which he is writing."

Well, in the *Times* of May 16th, Sir John Pender's letter to the Agents-General contains these words:—"The Eastern Extension Company is prepared to reduce the tariff between Europe and Adelaide, from January 1st next, from 9s. 4d. to 5s. per word."

What, then, becomes of the accusation of ignorance made by Mr. Finch-Hatton? Let me recommend him in return to cultivate modesty and accuracy.—Yours, &c., J. HENNIKER HEATON.

June 9th.

PARLIAMENTARY INTELLIGENCE.

Central London Railway Bill.

On the order for the consideration of this Bill in the House of Commons on Friday evening last,

Mr. BOULNOIS moved that the Bill be considered this day three months. There was the strongest possible objection to the proposed railway on the part of the shopkeepers of Oxford-street. They objected that an experiment such as this involved should be made in such an important thoroughfare as Oxford-street, Holborn, Newgate-street, and King William-street. They objected to such a line of route being handed over to a body of speculators, who had not the slightest knowledge of the scheme they proposed to introduce. He said that advisedly, because this was an electric railway, and there was no experience in this country of the success of such a railway. There seemed to be no necessity for it at all, because it would not relieve the vehicular traffic, nor would it do anything for the cross traffic from north to south, which was the source of so much danger and delay, and it was, moreover, not a railway which would facilitate intercommunication of passengers by different railways, such as the Metropolitan and District Railways afforded.

Mr. G. BRUCE, in seconding the motion, urged that Holborn was not a district where an experiment of this kind should be tried. The Select Committee which had considered this Bill had not been able to make up their minds about it, because they had inserted a clause preventing the promoters issuing their prospectus or raising their capital till after three months' experience of the working of the City and Southwark Subway. That showed that the Committee itself had not been satisfied this was a practicable scheme.

Mr. T. H. BOLTON suggested the adjournment of the debate in order to give the local authorities or freeholders interested an opportunity of considering the question of obtaining compensation from the promoters for the use of the ground underneath the roadway.

Sir C. LEWIS submitted that no public ground had been suggested why the ordinary course should not be taken in connection with the present Bill, since it had been duly considered by a Committee of the House. The great problem to be solved was how to manage the ever-increasing traffic of the metropolis.

Mr. P. STANHOPE said they had heard nothing from the opponents of the Bill which would justify its rejection, and he hoped no more time would be wasted in the discussion.

Sir H. SELWIN-IBBETSON must point out with regard to the proposal to shelve this Bill for six months that the Holborn Division supported this Bill, while the St. Giles Division, which opposed the Bill on clauses, had withdrawn their opposition when the clauses were agreed upon. The proposal, therefore, to reject the Bill was made on insufficient evidence. His advocacy of the Bill was based on the inadequacy of the accommodation of the traffic. He believed that the scheme under the Bill would relieve the congested traffic, and he hoped the House would support the decision of the Committee.

Mr. W. JAMES also supported the Bill, and said that it must be apparent to everyone that it was necessary to do something to relieve the traffic. He regarded the opposition as rather of a selfish kind.

Sir J. PULESTON pointed out that three of the most eminent architects and engineers had given their opinion that the line, if constructed, would involve no risk to St. Paul's, the character of the subsoil being favourable for the construction of a tunnel, and the distance it would be from the foundations of the building being sufficiently great. All the public bodies of the district were in favour of the formation of the line, which would be a great convenience.

Sir E. GREY, as one of the members of the Committee before whom the Bill came, said that the measure had been under their consideration for 13 days, and the decision which had been come to had been arrived at after a careful review of the whole of the evidence that had been laid before them. The opposition to the measure arose out of local and not wholly disinterested prejudice.

Mr. BRUNNER pointed out the danger of the House setting a precedent of handing over to private companies the land under the streets of the metropolis, which was of enormous value. In New York such land was disposed of for the benefit of the city.

Mr. CREMER, while in favour of the nationalisation of all our highways, hoped that the House would mark its opinion of the character of the opposition to the measure, which came from a handful of wealthy tradesmen, who allowed their selfish interests to outweigh the public convenience.

Mr. J. ROWLANDS said the House ought to express an opinion that in future when a Committee had to consider a Bill of this description it would be expected to make some terms for the community. In this case the Company proposed to go to so great a depth that they did not require to take any premises on the surface, and thus they avoided the ordinary difficulties of compulsory acquisition. But the community had some interests in these railways, which were the railways of the future, and it ought to be understood that in the form of a royalty or in some other way the rights of the community should be preserved, and should not be altogether parted with to private companies.

The motion was then agreed to, and the Bill was put down for the third reading.

Electric Lighting Acts Amendment (Scotland) Bill.—This Bill was read a second time in the House of Commons on Thursday last week.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *May* 30, 1890.

Electrical Execution.—The Supreme Court of the United States has refused to grant the writ of error which was applied for in the Kemmler case. As might have been expected, the Court held that electrical execution was not such a cruel and unusual form of punishment as was intended in the prohibitory clause embodied in the constitution of the United States. Legal resources have now been exhausted, and it seems quite certain that Kemmler will meet his well-deserved fate by the means prescribed in the statutes, unless he should be pardoned—which is decidedly improbable.

Consolidation of Electrical Interests.—Rumours of consolidation between the Thomson-Houston Electric Company and the Edison Company have been revived, this time in more definite form and with some appearance of probability. If such a combination should be formed, it would leave the control of the electric lighting and power industries practically in the hands of two companies—the Westinghouse Company and the new combination. Whether the Westinghouse Company under those circumstances would fight or become a party to a great electrical trust remains to be seen. The Westinghouse Electric Railway Company is working actively to secure contracts; and although it is not yet ready to deliver the requisite machinery, it is likely that the early summer will see several Westinghouse electric roads.

The Rapid Transit Problem in New York.—There is great interest in New York just at present on the rapid transit problem. Suggestions are being continually made that the only solution of the above lies in a four-track underground railway, reaching practically the entire length of Manhattan Island. This view of the case is probably correct, for the elevated roads are totally unable to handle the enormous population that daily migrates back and forth in the business portion of the city. The surface roads are of little assistance, and unless the cable railway scheme at present before the public should succeed, and thereby delay the coming of genuine rapid transit, it is quite probable that steps toward an underground system will be taken in the near future. If anything of the kind should be attempted, it may be regarded as almost certain that electricity will be the motive power.

The Underground Mains Question in New York.—There seems to be great difficulty in securing underground conduits for the electric wires in this city, the subway companies being quite unable to furnish material fast enough to suit the Board of Electrical Control. Mayor Grant seems disposed to throw every possible obstacle in the way of the electric light companies. His latest move is an attempt to close the streets by forbidding the taking up of pavement for the purpose of making connections with subways. At the last meeting of the Board of Electrical Control he went so far as to demand from the Board and its experts some method for making connection for house service without moving the pavement at all. What might have seemed a righteous indignation in the early days of his proceedings against electric lighting, was, it is now evident, bitter personal opposition towards any propositions that come from the electric light companies. If the electric light companies were less scrupulous, perhaps work might proceed more rapidly.

CORRESPONDENCE.

THE PERMEABILITY OF IRON AT RIGHT ANGLES TO THE DIRECTION OF MAGNETISATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—Seeing the commencement of Mr. Kennelly's articles in last week's *Electrician*, and noting your editorial remarks on them, we think it might in some measure contribute to the elucidation of this matter if we detail to you some experiments made by us in March last.

Starting from the idea suggested by Mr. Swinburne during the discussion on Dr. Hopkinson's address that it should be possible on the Weber hypothesis to get increased permeability in iron by magnetising it first in one direction and then in another at right angles to it, we proceeded to investigate the point as follows:—A ring of inch square Lowmoor iron had a groove turned in it, and a lid made to fit it very accurately.

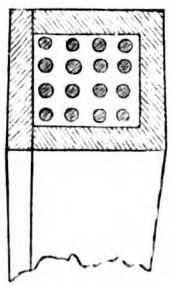

FIG. 1.

The sketch (Fig. 1) shows a section of the ring and coil. Inside the channel thus prepared was laid a coil previously wound on a former with a secondary coil, by means of which the induction produced by it could be measured. We call induction in this direction *transverse* induction. The lid was then fitted on, the ends of the coils coming out through two small holes. Another primary and secondary were then wound on the ring in the usual manner at right angles to the former pair, and producing *longitudinal* induction in the direction of the grain of the iron. The force-induction curve of the iron in each direction was then taken in the usual manner, after all traces of induction at right angles to the direction under investigation had been removed as far as possible by repeatedly putting the iron through the required cycle.

The results of our investigations were as follows:—The curves for longitudinal and transverse induction taken independently in the usual manner are shown in the upper curves in Fig. 2.

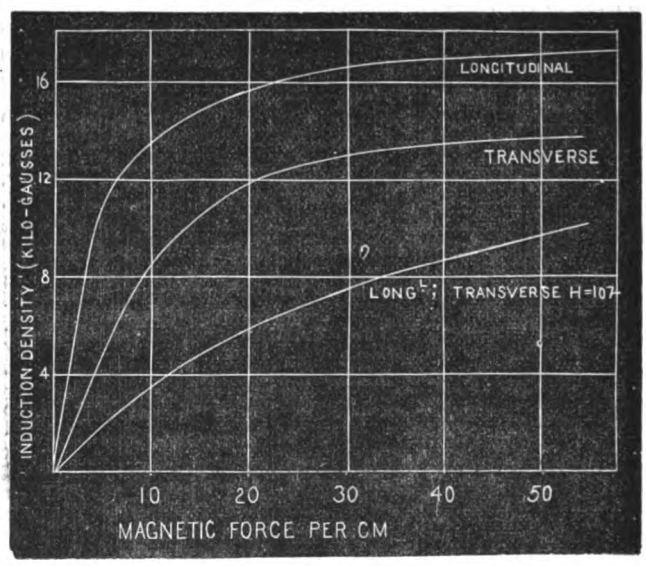

FIG. 2.

The lower values for the transverse induction are presumably partly due to the grain of the iron, and partly to the joint. We then took a longitudinal curve, applying and removing a strong transverse magnetising force between each observation. The result is seen in Fig. 3, which shows how nearly the points obtained after thus "joggling" the iron fall on the ordinary curve. Practically the two curves are identical. A longitudinal curve was then taken, a transverse magnetising force of 100 C.-G.-S. units remaining on all the time. The upper and lower curves on Fig. 2 show the force-induction curves for the longitudinal direction without and with transverse magnetisation. The permeability shows a

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large decrease, due, of course, to the fact that the plane of the induction alters with each alteration of the transverse magnetisation; and the secondary only measures the *component*, so to speak, of the induction at right angles to itself.

This experiment shows that for such forces as we were dealing with, *no* increase of permeability takes place. And, indeed, after making these experiments and thinking over the matter carefully, the following seemed clear to us:—The iron must be totally unconscious of *two* magnetising forces; it only feels *one* force, due to the resultant of the two, and an induction is produced in that direction, so that if we knew the length of the path of induction, we could probably predict its value.

Why, then, should the component of the induction in the longitudinal direction be greater than it would be if there were no transverse magnetising force? On thinking it over, we could see no reason why it should be, and it was not. The phenomena, however, lay somewhat outside the limit of our researches, and we therefore followed them no further. The above considerations, however, seemed to us common sense; but it is true that no amount of common sense, much less mathematics, appears to enable one to predict what molecules will do under untried circumstances.

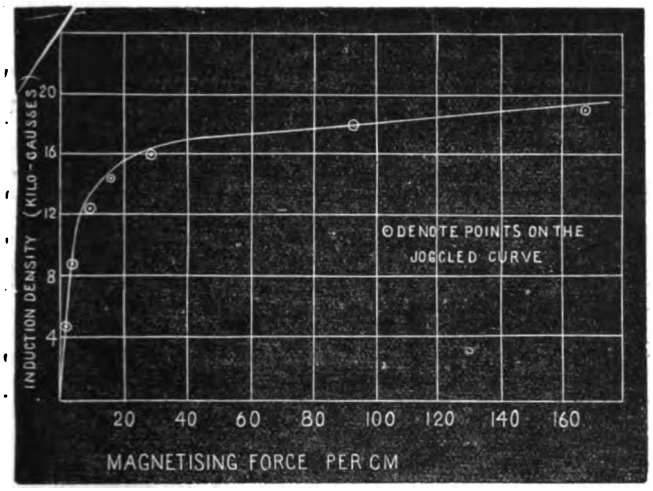

FIG. 3.

It may be noted that while our experiments, as we have already stated in another place, distinctly contradict Prof. Ewing's ideas on instability as far as regards masses of iron of the size used by us—that is to say, no amount of hammering could remove the residual induction—the very smallest magnetising force, applied at right angles to this residual induction, removed it entirely. This property might be utilised to eliminate hysteresis errors in a measuring instrument.

Our results, in short, show, as far as they go (1), That no such increase of permeability, as anticipated by Mr. Swinburne on the Weber hypothesis, actually takes place; and (2), That no increase of permeability in one direction takes place when a constant transverse magnetising force is maintained.

May we, in conclusion, suggest to Mr. Kennelly that his results would be more palatable and more easily comprehensible if they were expressed in curves, as well as in his pages of appalling figures? Apologising for the length of this communication,—Yours, &c.,

SYDNEY EVERSHED,
ERNEST B. VIGNOLES.

Woodfield Works, Harrow-road, W., June 10, 1890.

P.S. The experiments described above have nothing whatever to do with the initial part of the force induction curve for iron, to which so large an amount of attention has been devoted, and which is of so little practical importance.

[Although the magnetising forces in these experiments were at right angles to each other, they were of such magnitude that neither was perpendicular to the induction produced. This can only be the case when, as in Mr. Kennelly's experiments, one of the forces is small compared with the other. In fact, the forces dealt with by Messrs. Evershed and Vignoles were large enough to shift the induction round, making it cross joints and altering its course altogether; and the influence of this alteration was far more important than the alteration of what might be called specific magnetic resistance. We trust that the curves which appear this week will make Mr. Kennelly's results more palatable and comprehensible.—ED. *E.*]

PHOTOGRAPHS OF ELECTRIC DISCHARGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have recently taken several photographs of spark discharges from a Wimshurst machine, and of which I send you four. The length of spark was about 3in., while you observe that of the photographs is about 1½in.; this was as close as I could get the camera to the terminals without the brass work of the lens affecting the working of the machine. The sparks, you will notice, have a very zigzag course, some of them being much thicker at one end than at the other, while that of No. 1 is very thick throughout its length. The dry plates I used for Nos. 1, 2, and 3 (reproduced above) were the Ilford Special Rapid, and for that of No. 4 the ordinary make. Lately I have by means of a 4in. compound condenser thrown the enlarged image of the spark on a screen. The effect is then very brilliant, although the utmost length of spark I could get in the room in which I experimented was 6ft. or 7ft. A curious optical effect occurs in the enlarged image. Immediately the

bright spark ceases on the screen, a black streak appears of exactly the same shape and in the same place as the bright spark, and seems to remain on the screen for a short time, and gradually fade away.—Yours, &c., W. GILLETT.

Slough, Bucks, June 6, 1890.

THE WIRING OF HOUSES FOR THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the article on house-wiring in your last week's issue, there are some remarks therein which may be most unfavourably read in connection with small firms.

Although there are a large number of firms who have taken up the electric lighting business without any previous experience or technical assistance, this is not entirely the case; and it is in the interest of those qualified to do the work that I am now writing. Many of these small firms consist of men who, having had some years with a good and well-known firm, have now commenced business for themselves, and, thanks to careful personal supervision, turn out better work than their larger rivals, who in many cases leave the work in the hands of students and incompetent foremen. It is uphill work starting a new business, and a word from almost anybody will frequently spoil probable business. Only this morning I was told by a shopkeeper, to whom I had quoted a price, that he had been advised that my price was far too low for good work, and he preferred to put the job in the hands of some well-known firm that he could rely upon. (Said adviser has *two* years' electrical experience as against my *eighteen*, nine of which have been with electric light work of all

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kinds.) Were that man to read the remarks I refer to in your paper, he would doubtless be strengthened in his belief that I was going to give him something cheap and nasty; and yet I will guarantee the quality of all the material quoted for to be above the average for shop work. The workmanship, too, I could guarantee, as I pay wiremen 9d. per hour and keep only the best. Good men are fully worth it. I may also mention that the estimate showed a gross profit on outlay for labour and material of 36½ per cent., which is quite high enough for a well-managed business.

I think, Sir, in the face of the above, it is hard on the small men to be indiscriminately condemned in a leading technical paper such as yours is, although I do not suppose for one moment the remarks were meant in their widest sense. My object in writing is simply to prevent, by your kind assistance, the publication of any similar remarks which may, unintentionally, do harm to trustworthy men.—Yours, &c., A. I. E. E.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

St. Pancras Electric Lighting.—Extension of Time.—It will be seen from our advertisement columns that the time for sending in tenders has been extended from June 23rd to June 30th.

Tenders Invited.—The Town Commissioners of Dundalk invite tenders for lighting the streets of the town by electricity, gas, or oil (gasoline). A contract would be taken for a period of one or more seasons, consisting of ten months (from August 1st to June 1st). Service one hour after sunset to one hour before sunrise. The number of town lamps in present use is 185. Mr. Edward Ferrar, town clerk, Town Hall, Dundalk, will supply all particulars. Tenders will be considered at the meeting of the Commissioners on Wednesday, June 25th.

Tender Accepted.—We understand that the tender of Messrs. Percy Huddleston and Co. has been accepted by the Metropolitan Asylums Board for the electric light cable advertised in our issue of May 23rd, as lying on shore abreast the training ship "Exmouth," off Grays, Essex.

Patent Litigation.—We understand that the Courts will shortly be engaged in settling the rival claims of two manufacturing and supply companies to patents for electrical apparatus, &c. We hope to hear that matters will be arranged without recourse to litigation.

Messrs. Charlesworth, Hall and Co.—We have received from Messrs. Charlesworth, Hall and Co. the newly-issued, neatly-printed sheet "A. N." of price lists of their well-known dynamos. Hall's patent "Oldham" dynamo is illustrated, as well as a steam dynamo for 60 amperes, at 65 volts, at 500 revolutions per minute. Views are also given of a dynamo for 280 amperes; of a dynamo and turbine; of a dynamo arranged to be driven by a gas engine for 150 amperes, at 100 volts, at 670 revolutions per minute; and of a well-made electro-plating dynamo for 1,000 amperes, at 10 volts, at 800 revolutions per minute. The commercial efficiency of these machines is stated to be up to 96 per cent.

Messrs. Blenheim and Co.—We have received from Messrs. Blenheim and Holland a notification that, as announced in our last issue, the partnership carried on at Egham, Surrey, under the style of Messrs. Blenheim and Co., electrical apparatus and telephone manufacturers, has been dissolved by mutual consent. We are further notified that the business will be carried on as usual by Mr. W. Blenheim alone as from May 31st last.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

May 14, 1890.

7,513. W. L. Wise. London. Improvements in the manufacture of electrodes for secondary batteries (P. Schoon, Switzerland).

7,518. A. Walker and T. J. D. Rawlins. London. Improvement in means for preventing polarization in primary batteries.

7,540. W. L. Wise. London. Improvements in electric arc lamps (La Société Japy Frères, France).

May 15, 1890.

7,553. E. F. Furtado. London. Improvements in electro-telephonic apparatus.

7,560. C. R. C. Smyth and E. Payne. Glasgow. Improvements in and connected with ammeters and voltmeters.

7,572. F. Suter. London. Electric sign.

7,581. W. A. Thoms, London. Improvements in the electro deposition of heavy metals and their alloys.

7,599. R. Belfield. London. Improvements in electric arc lamps (P. Lange, United States).

May 16, 1890.

7,618. J. P. Bayly. London. Improved electrical device for use in dental operations (C. W. Manker, United States).

7,619. J. P. Bayly. London. Improved galvanic apparatus for use in dental surgery (C. W. Manker, United States).

7,624. J. A. Kingdon. London. Improvements in electrical transformers.

7,663. E. Fischinger. London. An improved method of and means for distributing electric current in central systems.

7,670. C. D. Abel. London. Electric meter (La Société Anonyme Continentale, France).

7,674. J. A. Jobling. London. Improvements in the manufacture of glass shades for electric lamps.

May 17, 1890.

7,725. C. E. Challis and G. Graham. London. Electric switches.

May 20, 1890.

7,819. G. J. Larner. Darenth, near Dartford, Kent. Timing the arrival of a homing pigeon by electrical means.

7,836. F. Stitzel, C. Weinedel, M. J. Schwartz, A. Reutlinger, J. H. Egelhoff and J. Kreiger. Glasgow. Improvements in electric semaphores for railways.

7,853. W. P. Thompson. Liverpool. Improvements in welding metals electrically, and apparatus therefor (C. L. Coffin, United States).

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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7,867. H. H. LAKE. London. Improvements in electric motors (The Giant Electric Motor Company, United States).

7,871. O. W. HART. London. Improvements in electrical signal circuits.

7,876. H. H. LAKE. London. Improvements in methods of and apparatus for melting, refining, and casting metals and other substances by electricity (E. A. Colby, United States).

May 22, 1890.

7,981. E. SECHÉHAYE. London. Improvements in dynamos and electro motors.

7,988. C. L. COFFIN. Liverpool. Improvements in welding metals electrically. (Date applied for under Patents Act, 1883, Sec. 103, 6th November, 1889, being date of application in United States.)

7,989. C. L. COFFIN. Liverpool. Improvements in welding metals by electricity. (Date applied for under Patents Act, 1883, Sec. 103, 12th November, 1889, being date of application in United States.)

7,990. C. L. COFFIN. Liverpool. Improvements in electric welding. (Date applied for under Patents Act, 1883, Sec. 103, 19th November, 1889, being date of application in United States.)

7,991. C. L. COFFIN. Liverpool. Improvements in electric welding. (Date applied for under Patents Act, 1883, Sec. 103, 19th November, 1889, being date of application in United States.)

7,992. C. L. COFFIN. Liverpool. Improvements in electric welding. (Date applied for under Patents Act, 1883, Sec. 103, 19th November, 1889, being date of application in United States.)

7,993. C. L. COFFIN. Liverpool. Method of welding metals electrically. (Date applied for under Patents Act, 1883, Sec. 103, 6th December, 1889, being date of application in United States.)

7,994. C. L. COFFIN. Liverpool. Method of welding metals electrically. (Date applied for under Patents Act, 1883, Sec. 103, 12th December, 1889, being date of application in United States.)

May 23, 1890.

8,036. R. W. EDISON. London. An improved insulated electric conductor (G. Niemetz, Austria).

8,041. A. MACGREGOR. Manchester. Improvements in the construction of reaping and mowing machines.

8,076. G. WILKINSON. London. Improvements in the distribution of electric energy.

8,110. G. FORBES. London. Improvements in electric regulators and meters of which such regulators form a part.

May 24, 1890.

8,114. G. PARFITT. Bristol. Improvements in electric light fittings.

8,115. G. PARFITT. Bristol. Improvements in electric light fittings.

SPECIFICATIONS PUBLISHED.

1889.

10,082. BIKSWANGER. Electric switches, &c. (Price 8d.)

11,046. THOMPSON. (The Westinghouse Electric Company). Electrical cores. (Price 8d.)

11,296. RYDER and DOPSON. Electric incandescent lamps. (Price 8d.)

11,436. NEWTON (Main). Electric motors. (Price 1s. 6d.)

11,589. CROMPTON. Electric conductors, &c. (Price 8d.)

18,355. GIBBS and FESQUET. Secondary generators. (Price 8d.)

1890.

2,957. AUBERT. Electric counters. (Price 6d.)

2,963. SAYER. Electric railways, &c. (Price 1s. 6d.)

Amended Specifications.

1886.

16,408. BOULT (Dujardin). Electric accumulators. (Price 8d.)

Second Editions.

1886.

1,161. THOMPSON (Cowles). Electric furnaces. (Price 6d.)

2,403. HADDAN. Electric smelting furnaces. (Price 8d.)

CITY NOTES, &c.

BELL TELEPHONE COMPANY.—This Company has declared the regular dividend of 3 per cent., with 6 per cent. extra, payable July 15.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this Company for the week ended June 6, 1890, amounted to £4,094.

COLUMN PRINTING TELEGRAPH COMPANY (LIMITED).—The prospectus of this Company has been issued this week. The Company has been formed for the purpose of acquiring and working Messrs. Moore and Wright's patent for printing by electric telegraph political and general news, stock lists, racing results, despatches, and bulletins of all kinds. The secretary is Mr. W. P. Forbes, and the offices are at 5, New Bridge-street, Blackfriars, E.C. The list opened on Wednesday, and closes to-day (Friday) at 4 p.m. The capital of the Company is £100,000, and the present issue is for 50,000 shares of £1 each, of which 10,000 have been reserved as part payment for the vendor, and 40,000 are now offered for subscription, payable 5s. on application, 10s. on allotment, and the remainder in instalments, if required, at intervals of not less than twelve months.

EXCHANGE TELEGRAPH COMPANY (LIMITED).—With reference to the prospectus noted above, the Exchange Telegraph Company (Limited) state that they are prepared now, as in 1882, to supply column printing telegraph instruments for the diffusion of news, and add that the statement contained in the prospectus that the Moore and Wright machine is unsurpassed in speed is inaccurate, the speed, as taken by competent observers, being much less than that of the column printer of the Exchange Telegraph Company. The type of Messrs. Moore and Wright's machine is also smaller. Another statement in the prospectus is that there are over 1,000 type-printing telegraph instruments in use in London; the Exchange Telegraph Company also contest this point, and add that the field for the employment of telegraphic type-printing instruments is limited.

NORTHAMPTON ELECTRIC LIGHT AND POWER COMPANY.—The first annual meeting of shareholders was held last week. The Directors' report stated that the site in Angel-lane had been secured at a net cost of £810, after selling off some of the frontage to the Corporation. Contracts had been entered into with Messrs. Green Brothers for erecting the necessary buildings and laying the mains; and orders for engines and dynamos, representing an expenditure of some £5,000, had been given. The report, which spoke hopefully of the prospects of the Company, and acknowledged the indefatigable services of Mr. Montague Browne, the secretary of the Company, was adopted.

POOLE AND WHITE (LIMITED).—The statutory meeting of this Company will be held at the offices, Bread-street, E.C., this day (Friday) at 12 o'clock.

SOCIETE GENERALE DES TELEPHONES.—The general meeting of this Company will be held on the 18th inst., when a dividend of 25 francs per share will be announced. The profits from the manufacturing business alone amounted, during the past year, to 1,680,000 francs, of which 600,000 francs will be carried to the reserve fund.

THE DEVELOPMENT OF ELECTRIC TRACTION.—We hear that a new company will shortly be brought out with a million capital for the development of electric traction on the Thomson-Houston and Series systems. Contracts are said to have been entered into to the extent of about three-quarters of a million for equipping tramways in various parts of the country, and experiments will also be made on the Metropolitan District Railway between Acton and Hounslow.

UNITED RIVER PLATE TELEPHONE COMPANY (LIMITED).—Notice is given that the transfer books of the Five per Cent. Debenture Stock of this Company will be closed from the 16th to the 30th inst., both days inclusive, for the purpose of preparing the half-yearly interest warrants.

WESTERN UNION TELEGRAPH COMPANY.—The Directors of this Company have declared a quarterly dividend of 1¼ per cent.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended June 6, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,143.

THE NON-CONDUCTOR OF ELECTRICITY.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 2ft. 6in., varying in thickness from 1-50in. to 1in.

FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Divi-dend.	Name.	Previous Week's Price, June 4.		Price Wednesday, June 11.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 11.	
£			**TELEGRAPHS.**					£ s. d.		Highest.	Lowest.
1,381,380	Stock	12/6	Anglo-American	50	51	50½	51¼	5 6 10	Jan., Apr., July, Oct	51½	50½
2,809,310	Stock	25/0	Do. Preferred	86½	87½	87	88	6 5 0	,, ,,	87¾	86⅞
2,809,310	Stock	..	Do. Deferred	15½	16	15⅞	16⅛	..	February	15⅞	15½
25 ,000	£100	4%	African Direct, 4 per Cent. Debentures	98	101	98	101	3 19 3	January and July	..	..
130,000	10	3/0	Brazilian Submarine	11⅜	12⅛	11⅜	12⅛	6 2 5	Mar., June, Oct., Dec.	12⅛	11⅛
69,200	100	5%	Do. 5 per Cent. Bonds	101	104	101	103	4 17 1	January and July	102½	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	106	109	106	109	4 11 9	June and December	..	..
..	$100	..	Commercial Cable	..	..	106	106½	..	..	..	..
16,000	£10	9/0	Cuba Submarine	11¾	12¼	11¾	12¼	7 6 11	February and August	12⅛	12
6,000	10	10%	Do. Preference 10%	17½	18½	17⅛	18⅛	5 8 1	,, ,,	17⅛	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3⅜	4¼	3⅜	4¼	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 14 11	Jan., Apr., July, Oct.	10⅛	..
400,000	10	2/6	Eastern	13⅜	14⅛	13⅜	14	4 12 10	,, ,,	14⅛	13⅜
70,000	10	6%	Do. 6 per Cent. Preference	14¾	15¼	15	15½	3 17 5	,, ,,	15⅜	13¼
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107	110	107	110	3 12 9	May and November	108	107
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	13⅜	14¼	13⅜	14	5 0 0	Jan., Apr., July, Oct.	14⅛	13⅛
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101	103	101	103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 per Cent. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	,, ,,	..	..
180,227	10	2/0	Globe Telegraph and Trust	8⅞	9⅛	8⅞	9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅝	15⅛	14⅝	15⅛	3 19 4	,, ,,	15⅞	15
150,000	10	5/0	Great Northern	15⅞	16⅛	15⅞	16⅛	4 12 4	Jan., July, and April	..	..
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102	105	102	105	4 15 3	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	38	40	37	39	6 8 2	April and October	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅜	8	7⅜	8⅛	6 1 3	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	110	115	112	116	..	,, ,,	..	..
15,609	£10	3/6	West African	9	10	9	10	..	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	101	..
30,000	10	2/0	West Coast of America	5⅜	6	6⅜	7	8 11 5	January and July	7	6⅜
150,000	100	8%	Do. Debentures 8%	111	116	111	116	6 17 11	June and December	114½	..
88,321	10	Nil.	West India and Panama	2⅜	2⅝	2⅜	2⅝	..	..	..	..
34,563	10	6/0	Do. 1st Preference 6%	11	11½	11	11½	5 4 4	April and October	11⅝	11¼
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12⅜	13⅛	12⅜	13⅞	..	..	..	..
64,572	15	6/0	Western and Brazilian	9⅞	10⅛	9⅞	10⅛	6 10 1	May and November	10⅛	9⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅛	6⅞	6⅛	6⅞	..	..	..	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3⅜	4	3⅜	4	..	..	3⅞	3⅜
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	..	108	106⅛
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	123	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5¾	Consolidated Telephone Const. and Maintenance	⅛	⅜	⅛	⅜	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼	⅜	¼	⅜	4 8 3	Yearly	..	..
386,375	5	3/0	National	5⅛	6	5⅛	6	..	June and December	6	5⅞
49,825	5	1/4½	Do. New	5⅛	6	5⅛	6	..	..	5⅛	5⅛
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference	12⅛	13⅜	12⅛	13	4 12 4	June and December	12⅛	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference	10¼	10⅞	10¼	10⅞	..	,, ,,	..	..
209,750	1	..	South of England, Ordinary	⅛	..	⅛	..	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3¼	3⅞	3¼	3⅜	..	..	..	..
55,000	5	2/0	United River Plate	4⅛	5	4⅛	5	..	January and July	4⅜	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..	..	..	..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2½	3	2½	3	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5⅛	5⅜	5⅛	5⅜	..	..	5⅝	5⅜
42,853	5	..	Westminster Electric Supply	1⅞	2⅛	1⅞	2⅛	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅝	2⅞	2⅝	2⅞	..	..	2⅞	2⅞
63,416	2	1/2	Do. Preference	1⅞	2	1⅞	2⅛	5 12 11	..	2⅛	2
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares	5⅛	5⅜	5⅛	5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
409,000	10	..	Electric Construction	9⅞	10⅛	9⅞	10⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	4⅜	5⅛	4⅜	5⅛	..	..	5⅜	4⅛
20,000	5	..	Fowler-Waring Cables	2⅛	2⅜	2⅛	2⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19½	20½	19½	20½	4 17 7	February & August	19¾	19¼
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5⅛	5⅜	5⅛	5⅜	3 13 0	..	5⅜	5⅛
37,350	12	36/0	Telegraph Construction and Maintenance	44	46	44	46	5 3 11	March and July	46	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	..	..	..

JABLOCHKOFF'S **DISTRIBUTION PATENT**

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL O

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

The exhibits of the Royal Society's second *soirée* were in many cases the same as those shown on May 14th. Prof. Thompson showed Kœnig's experiments on beats and beat tones; and amongst the new exhibits were some photographs of lightning flashes, shown by the Royal Meteorological Society, and some interesting photographs of musical sparks by Sir A. C. Campbell. Two Hughes' telegraphs were shown working direct to Berlin, Paris, and Rome. Among the most interesting features of the evening were Dr. Fleming's electro-magnetic repulsion experiments, several of the most striking of which had not been shown before. One of the new Thomson alternate-current motors was seen in action, being driven by a transformer fed from the neighbouring circuit. As is well known, this motor is started by rectifying the currents through the armature by a commutator and brushes; but when synchronism is attained the armature is automatically short-circuited, and the brushes may be removed.

The Electrical Trades' Committee was occupied at its last meeting with matters of considerable commercial importance; and, as usual, the actions of the Board of Trade and of the Local Authorities were the subjects discussed. That the neat-looking Rule 9 of the Board of Trade's regulations with regard to the insulation of overhead wires should have resulted in converting electrical cables into "puddings," is an example of the danger of drawing up rules without taking the trouble to see what they lead to; and the announcement made by Mr. Garcké that Local Authorities to whom concessions have been given are seeking to impose onerous if not impossible conditions upon contractors desirous of undertaking the actual work, is but the logical consequence of granting these bodies so many privileges. No doubt, as a relief to these somewhat sombre topics the Committee, as will be seen by our Notes column, devoted the remainder of its time to the organisation of a river excursion. A quiet run up the Thames in an electric launch will perhaps prove a pleasant relief from unworkable Board of Trade rules and regulations and the exactions of Local Authorities.

On more than one occasion we have alluded to experiments undertaken with the view of determining whether the passage of an electric current between the wheels of a car and the rails does or does not increase the adhesion between them; the general result of these experiments tending to show that, unless the currents used are stronger than those generally employed on electric railways, no such effect takes place. We publish this week an account of the work of Mr. Ries, who claims to have been the first to call attention to this matter. His experiments have been carried out in a much more satisfactory manner than any we have yet noticed. The current used with the idea of increasing the traction was generated for that purpose only, so that by suddenly switching it on or off its effect could be with certainty detected; and as some of the experiments were made on an engine weighing 50 tons, used to draw a train of a dozen loaded coal waggons with the brakes in action, the practical magnitude of the forces dealt with is sufficiently indicated. The increase of over 25 per cent. in the tractive adhesion, found in such experiments, is to be accounted for by the heating effect at the surface of contact, caused by the passage of the current, this being of sufficient magnitude to produce an instantaneous weld. The currents required are much larger than those employed in common systems of electric traction; but the energy required to generate them is stated to be small compared with that needed for locomotive purposes, so that a new and highly promising application of electricity is disclosed. The current used as a traction increaser is generated quite independently of any used for motive power, and it is evident that the discovery may be adapted to all locomotive cars and need not wait for the development of electric traction for its application. It is satisfactory to note that extensive experiments are to be carried out under conditions which will thoroughly test the capabilities of the method. The discovery will be of comparatively little use unless applicable when the speed of the locomotive is fairly high; and for this reason special attention should be directed to the connection between the current density required and the velocity of the train.

In a short but instructive Paper, which will be found in another column, Lieut. Wilkes, of the United States Navy, usefully points out what a great field modern navies offer to the most important branches of applied electricity. The electric light has long ago become indispensable to every man-of-war; and at the present moment both electric power and electric welding are being tentatively introduced on board ship. Naval yards are, moreover, a close approximation to the ideal as places in which to distribute current for the purposes of light and power. A dockyard central station has a compact area to deal with, and current is required both for street and house lighting, stationary motors, and electric welders; and probably, in

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the near future, electric traction will come into general use for the transportation of naval material from place to place within the yard.

THE eight requisites of a good marine dynamo detailed by Lieut. WILKES might, with little alteration, be made applicable to dynamos working in many of our London central stations, in which the underground situation renders compactness, cool running, and ability to dispense with frequent examination as important as in the case of a machine placed in the engine-room of an ironclad. The two main features which should distinguish a good marine dynamo from one intended for ordinary land service are, of course, freedom from liability to injury by salt water and complete absence of stray field. Neither of these desiderata would appear as yet to have been altogether satisfactorily fulfilled across the Atlantic.

A REMARKABLE effect of electric oscillations has been recently pointed out by Prof. MINCHIN in the columns of our contemporary, *Nature*. Two metal plates attached to platinum wires are sealed in a closed glass vessel containing alcohol. One of these plates has been previously sensitised by some process not described; and it is found that, if light falls upon this its potential differs from that of the second plate by more than half a volt, and may be detected by an electrometer. A slight tap will, however, render the cell insensitive to light; a second tap will restore the sensitive condition, and so on, the two states occurring alternately, and being indicated by the movements of the needle to and from the zero position. The influence of an electric spark on such a cell is still more remarkable. If the cell is in the insensitive condition, the sensitive state can be at once restored by simply causing a spark to pass between the terminals of a Wimshurst machine or of a Hertz oscillator. The effect takes place even if the spark is caused at a distance of many feet from the cell. Prof. MINCHIN explains the effects by assuming that the molecular state of the surface is altered, and assumes that light energy can be taken up electrically for one condition but not for the other. If this is so, there are probably many other instances in Nature; and thunderstorms and other electro-magnetic disturbances may considerably influence the manner in which the energy of sunlight is taken up by plants or utilised in other ways.

THE Patton Motor Manufacturing Company of Chicago has devised a system of electric traction distinctively its own. The basis of operation, we are told, is the "generation of electricity upon the vehicle, thus rendering each car independent and dispensing with overhead or conduit wires for the transmission of electric force." The "generation of electricity upon the vehicle" is effected by installing a gas engine and dynamo upon a separate car, the current from the dynamo when not employed in supplying the motor, charging a battery of accumulators arranged under the seats of the passenger car, "so that reserve force is always in readiness for any emergency." This idea reminds us of the ingenious proposal put forward some twelve months ago on the other side of the Channel, that each gas lamp should be surmounted by an arc light supplied with current from a dynamo driven by a small gas engine arranged in the base.

Junior Engineering Society.—Prof. John Tyndall, F.R.S., has accepted the position of vice-president of this society.

Lightning in Italy.—The number of deaths in Italy from lightning during recent years are as follows:—In 1883, 98; 1884, 201; 1885, 182; 1886, 137; 1887, 260.

The Lighting of the Eiffel Tower Lifts.—The lifts at the Eiffel Tower are now lighted by the electric light, the current for the lamps being obtained from a Renard battery.

Llanelly.—The Local Board have granted permission to the Llanelly Electric Light and Power Company to apply to the Board of Trade for a licence to supply certain districts of the town with electricity.

Electric Traction at Birmingham.—A trial was made on Wednesday evening last week of one of the accumulator cars about to be introduced on the Bristol-road line of the Central Tramways Company's system.

Berthoud-Borel Cables.—The latest type of Berthoud-Borel cable is insulated with layers of celluloid tape, over which a layer of hemp is wound, the whole being then plunged into a bath of hot liquid insulating compound.

The London County Council and Overhead Wires.—On Friday last the Select Committee of the House of Commons, presided over by Sir Joseph Bailey, passed the Bill promoted by the London County Council for regulating overhead wires.

A New Text Book.—We are pleased to see, from a note in the *Electrical Engineer* of New York, that Dr. Fleming's "Alternate-Current Transformer" (Vol. I.) has been adopted as a text-book in Physics IV. (Electrodynamics) at Harvard University.

The Central London Railway Bill.—The Corporation will oppose this Bill in the House of Lords in order to prevent the mutilation of the clauses which have been inserted by the Select Committee of the House of Commons for the protection of the City.

Society of Arts.—We are glad to note that the Society of Arts has awarded its silver medal to Dr. J. A. Fleming, for his excellent Paper on "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments," which appeared in these columns a few weeks ago.

The Halifax-Bermuda Cable.—The "Westmeath," with the Halifax and Bermuda cable on board, arrived off Bermuda on the 7th inst., and, having completed the necessary soundings, proceeded to Halifax, which port she reached on the 16th inst., and will at once commence to lay the cable.

The Royal Military Tournament.—At the Royal Military Tournament this year the armour-plated train with Gatling gun is drawn by a self-contained electro-locomotive, constructed by the Electric Construction Corporation. The use of electricity in this connection will be watched with interest.

Gevelsberg.—From the *Elektrotechnisches Echo* we learn that the town of Gevelsberg, Westphalia, a place of about 10,000 inhabitants, will be lighted by electricity from the end of September. The Tudor accumulator is to be used, and 1,500 lamps will be put up at first, the number being afterwards increased to 4,000.

The Lane Fox Patents.—The following are the royalties which the Lane Fox Electrical Company has finally decided to demand from the owners of private installations:—Private houses—1s. 6d. per 16 candle-power lamp, per annum; other installations—such as hotels, clubs and offices—2s. 6d. per 16 candle-power lamp, per annum.

Thunderstorms.—During a heavy thunderstorm at Lewes, on Thursday last week, a man was killed by lightning. At West Bromwich the wires connected with the telephonic apparatus at the Central Fire Station were struck by lightning. Several of the wires were melted, and communication with seven of the places connected was rendered impossible.

Swansea.—The work of lighting the whole of the Swansea Harbour Estate by electricity has just been completed. The previous installation had comprised merely the Prince of Wales Dock and the pier; but the trustees, finding the system worked well under the present management, resolved to light the whole estate. The work is of a thoroughly satisfactory character.

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Tory Island Lighthouse.—In answer to a question put in the House of Commons last week, Sir M. Hicks-Beach stated that the contract for the manufacture and laying of a cable connecting this island with the mainland would be signed in the course of a few days, and also the contract for the erection of the necessary buildings. It was believed that the signal station would be in working order within a few weeks.

Institution of Electrical Engineers.—We understand that the President was desirous of rendering the annual *conversazione* especially attractive, and with that view intended to have held it in a new *locale*. Every preparation had been made for this; but, unfortunately, at the last moment, the arrangement fell through. As it is now too late in the season to make any other arrangements, the *soirée* will be postponed until after the recess.

The Telegraph Clerks' Grievances.—In answer to a question by Earl Compton, with regard to the telegraph clerks' grievances, the Postmaster-General stated on Friday last that the Departmental Committee appointed in March had presented their report, and he hoped to be able to announce the decision of the Government at no distant date. One important change relating to sick pay was, he stated, carried into effect on June 1st.

The Australian Transcontinental Telegraph Line.—During 1888 the telegraph line connecting Port Darwin and Adelaide was interrupted eight times. Lightning and floods were responsible for most of these interruptions, which were all of brief duration; one, however, was due to three posts and twenty miles of wire having been stolen. On another occasion a wandering European cut the wire in order to bring the linemen to his rescue.

Burton-upon-Trent.—The Corporation, having been granted a Provisional Order, have issued a circular with a view of obtaining an idea of the probable quantity of electrical energy which will be required by private consumers. The maximum price allowed in Burton is eightpence per unit, and if the demand is limited that is the rate at which the Corporation propose to charge until they have obtained some experience as to the cost of production.

Technical Instruction.—The Lords of the Committee of Council on Education have decided, with the sanction of the Lords Commissioners of Her Majesty's Treasury, to allocate a fixed sum each year in the vote for the Science and Art Department for grants in aid of technical instruction given under the Technical Instruction Act, 1889, or under the Technical Schools (Scotland) Act, 1887. The sum so allocated for the financial year 1891-92 will be £5,000.

Agra.—There is every hope, says the *Indian Engineer*, that within the space of two months the Taj will be permanently lit up with the electric light. It is proposed to place 1,200 candle-power lights on each of the front minarets, and 1,000 candle-power lights on each of the back minarets and on the Musjid and Jawab. The main building will have no light stationed upon it, and so will be magnificently thrown into relief. The expense has been computed at Rs. 12,000.

Telephonic Contracts.—In the action Mordey, Carney and Co. *v.* Jacobs and Co., heard recently before the Newport County Court, the counsel for the defence submitted that there had been an unfortunate mistake. The negotiations, which related to a contract for towing a barque from London to Newport, were conducted by telephone, and the individual at the defendants' end of the line was hard of hearing occasionally, and the telephone was indistinct. These circumstances caused the misunderstanding. The Judge, however, gave judgment for the plaintiffs.

New Anglo-Scandinavian Cables.—The Great Northern Telegraph Company is contemplating laying down one or two new telegraph cables between Scandinavia and England. A cable will be laid between Gothenburg, on the Swedish side of the North Sea, and Newcastle-on-Tyne on the other side. This will be the first direct cable between Sweden and England. This new cable is expected to bring about a material increase in the Swedish telegraphic intercourse, as a large number of telegrams are likely to be sent by the new line from Russia and Northern Asia to England.

Obituary.—The death is reported of Mr. Thomas Brown Jordan at the age of 82. Mr. Jordan was born in Bristol in 1807, and established himself in Falmouth as a mathematical instrument maker, and effected improvements in the dipping needle and the miners' dial. About 1838 Mr. Jordan invented a declination magnetograph and a self-recording actinometer. From 1840 to 1845 Mr. Jordan held the appointment of first keeper of mining records. During this period he devoted considerable time to electro-metallurgy. He finally established himself in London as a mining and mechanical engineer in conjunction with his two sons.

A Remarkable Short-Circuit.—The *Electrical World* gives the following account of a peculiar accident that happened to the East Liverpool, Ohio, Western Electric Company a short time ago. The switchboard caught fire, the machine began "flashing," and the lights went out. Upon examination, it was found that an ordinary card photograph had by some means fallen into the switchboard, and the gilt edge around it had come in contact with the two ends of the line, causing a short circuit. The wires were separated from the switchboard, united temporarily with connectors, and everything was started up again with a stoppage of only a few minutes.

Barnsley.—At the last meeting of the Town Council, the Park and Lighting Committee reported that Mr. Bromley Holmes had given them information as to the tenders for an electric lighting plant. They also reported that the Barnsley Gas Company were ready to enter into a contract with the Council for lighting the street lamps in the borough; and as the terms were substantially those agreed to by the Council, the committee recommended them for acceptance, subject to six months' notice. A long conversation followed, and the report was eventually approved, it being stated that the final report of the committee on the electric lighting question would be in the hands of members a week before the next Council meeting.

The Tower Competition.—After careful consideration the Committee appointed to consider the designs for the proposed tower have awarded the prizes as follows:—First prize, 500 guineas, to Messrs. A. D. Stewart, J. M. McLaren, W. Dunn, 21, King William-street, Strand, W.C., joint authors of design No. 37. Second prize, 250 guineas, to Messrs. J. J. Webster and T. W. Haigh, 67, Lord-street, Liverpool, joint authors of design No. 51. The Committee consider the design No. 50, by Mr. Max am-Ende, deserves honourable mention. The Committee consisted of Mr. E. H. Carbutt (Chairman), Sir Frederick Bramwell, Sir Benjamin Baker, Sir E. J. Harland; Prof. Alex. B. W. Kennedy; Messrs. C. Liddell, J. F. Moulton, and Thomas Verity.

The Edison Lamp Patents in Germany.—The lawsuit brought by the German Edison Company against Messrs. Naglo, of Berlin, to which we referred in our issue of May 23rd, and which was decided in the favour of Messrs. Naglo, was chiefly noteworthy for a decisive report of Prof. Kohlrausch. In his report Prof. Kohlrausch stated that it was impossible to make an incandescent lamp according to the Edison patents of 1879, and that it was not until after the publication of Swan's patents that a practical incandescent lamp could be manufactured. Moreover, the report says that lamps similar to those of Edison existed before the granting of the 1879 patents, and that a filament of carbon being thinner or thicker could not form the basis of a patent.

Wimbledon.—A crowded meeting was held last week at the Drill Hall, Wimbledon, for the purpose of ascertaining the opinions of owners and ratepayers with regard to the scheme of the Local Board for lighting the town by electricity. Mr. Arthur Holland, chairman of the Electric Light Committee, gave an explanation of how the Board proposed to carry out their scheme. Several questions concerning the scheme were asked from the body of the hall, and replied to by Mr. Preece and Mr. Holland; but the answers failed to give satisfaction, in spite of the repeated declarations of the chairman that the meeting was not a public one. A resolution against the scheme of the Local Board was carried by a large majority, and the meeting broke up in confusion.

London County Council and the Board of Trade Regulations.—At the meeting of the London County Council last

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week the Highways Committee reported that they had had before them a letter from the Board of Trade, forwarding certain regulations for securing the safety of the public and for ensuring a proper and sufficient supply of electrical energy which the Board proposed to issue under the Electric Lighting Acts, 1882 and 1888, and asking for any observations which the Council might have to make with reference thereto. The Committee stated that, having carefully considered the proposed regulations, they had directed a letter to be sent to the Board, offering suggestions for some amendments which it appeared desirable should be made.

The Duplication of Telegraphic Communication with Australia.—On Friday last Sir G. Baden-Powell asked the Under-Secretary for the Colonies whether any definite proposal had been recently brought to the notice of the Colonial Office for duplicating telegraphic communication with Australia by means of a cable connecting with the African system, and touching at Mauritius; and whether Her Majesty's Government would view with favour such alternative communication, as being of great commercial and strategic value. Baron H. de Worms said that the answer to the first portion of the question must be in the negative. In reply to the latter portion he was sure that Her Majesty's Government would be glad to see such a line of telegraphic communication established.

A Correction.—Our attention has been called to an error in the table on the top of p. 71 of our issue of May 23rd. The order of the last two columns should be as follows, commencing at the tenth line:—

Mean sphr. C.P. per E.H.P.	Mean hor. C.P. per E.H.P.
159	184
179	203
210	244
141	177
157	191
185	217

The table occurs in Mr. Puffer's valuable Paper on incandescent lamp testing, which we abstracted from the *Electrical Engineer* of New York.

Bolton.—Messrs. Dobson and Barlow, of Bolton, have placed 650 incandescents in a portion of their extensive machine works. Should the electric light be ultimately adopted throughout the works, about 4,000 lights will be required. The shop, which has been fitted with the electric light, used to be almost unbearable from the heat and fumes of the gas, and since the adoption of electricity the average number of men on the sick list has been reduced. The electric light is also being adopted in the large printing works of Messrs. Tillotson and Son. It is likely that electricity will be adopted in the new North End Mill, one of the largest now being erected in Lancashire. The master drapers of Bolton are also agitating for a combination for supplying themselves with the light.

City of London and Southwark Subway Bill.—A Select Committee of the House of Lords, on Tuesday last, presided over by Lord Belper, passed this Bill. The Bill, it will be remembered, has already been sanctioned by the House of Commons, and authorizes the City of London and Southwark Subway Company to extend their line from its present terminus at Stockwell to Clapham Common. For the purpose of carrying out this extension of about one mile, the Company are empowered to raise £200,000 additional capital, and to borrow in respect of that capital the sum of £50,000. The name of the Company is changed into the "City and South of London Railway Company," and an extension of time is granted within which to complete the construction of the original line.

The Profits of the Paris Exhibition.—M. A. Neymarck has recently made a communication to the *Chambre Syndicale des Industries Diverses* of France, on the subject of the profits of the late Exhibition to France in general. Adding together the increase of the bank balances, of the receipts of railroads, of the revenue, &c., a total gain not far short of five hundred millions of francs is made out. To this must be added the strictly private receipts. Allowing one million and a-half of foreign visitors spending an average of 500 francs each, and six millions from the provinces of France spending an average of about 100 francs each, 1,250 millions appear as the private receipts, giving a total of 1,750 millions of francs direct monetary gain. The figure of £70,000,000 thus arrived at requires, however, close investigation before it can be generally accepted.

The Australian Cable Rates.—Mr. Jackson stated in the House of Commons on Thursday evening last week that it was a fact that the principal Australian Governments had made a proposal that the Imperial Government should join in the payment of a subsidy to cable companies, and also in the guarantee against loss on the proposed reduction of the rates by one-half; but that the Government had not acceded to the proposal.—A Melbourne cablegram, dated June 16, states that the Australian Governments, not being satisfied with the decision arrived at by the Imperial Government not to join the Colonies in bearing a certain proportion of the subsidies and guarantees to the cable companies, the Agents-General have been instructed to make further representations on the subject, with the object of inducing Her Majesty's Government to reconsider their decision in the matter.

Observations on Atmospheric Electricity in the Tropics.—In order to investigate the relations of atmospheric electricity to the moisture of the air within certain limits, Herr F. Exner has made observations of the fall of atmospheric potential in countries with high relative moisture, particularly in the Indian Ocean between Aden and Bombay, in Bombay itself, and in Ceylon both on the coast and in the interior. The measurements were made with transportable apparatus invented by Herr Exner. All the values of the fall of potential were positive. Near the coast the finely-divided spray arising from the breaking of the waves exerted an increased action on the fall of potential. On the other hand, measurements made in Cairo and the vicinity showed that there the dust of the air exerted a lessening influence on the fall of potential, which with a strong wind was so marked that the sign of the fall of potential became negative.

Electrical Trades' Section River Excursion.—At the last meeting of the Electrical Trades Section of the London Chamber of Commerce, it was proposed that the members of the Section should have an excursion on the river on Saturday, July 5th. Members who intend to be present should notify the same to Mr. A. P. Trotter, 28, Victoria-street, S.W., so that the necessary arrangements may be made. Members may bring friends (ladies or gentlemen), but no member can have more than four tickets, including his own. The price of the tickets (not including wine) cannot be definitely settled until it is known how many will be taken; but it will not exceed 12s., and if a fair number join this figure will of course be reduced. The list will close on Monday next, 23rd inst., at 10 a.m. The party will probably embark at about noon, thus allowing members time to open letters, &c., before starting. Members who desire to return early will be enabled to do so by train from some point up the river.

Manual Instruction.—With a view to develope this instruction in a practical direction, and to assist and encourage the formation of classes for manual instruction, grants will be made by the Department of Science and Art towards the maintenance of such classes in connection with elementary schools teaching drawing, or in connection with organised science schools under section 27 of the Science and Art Directory. The instruction must be in the use of the ordinary tools used in handicrafts in wood or iron, and the work must be from drawings to scale previously made by the students. The instruction may be given by one of the regular teachers of the school if he is sufficiently qualified; if not, he must be assisted by a skilled artisan. The work of the class will be examined by the local inspector of the Department, accompanied, if necessary, by an artisan expert on the occasion of his visit to examine the drawing. If it appears that the school is properly provided with plant for instruction, and that the teaching is fairly good, a grant of 6s., or if excellent, of 7s., will be made for every scholar instructed, provided certain conditions have been fulfilled.

The Quantity of Electricity in a Lightning Flash.—Assuming that a normal flash melts a copper conductor of 5 sq. mm. section, Prof. Kohlrausch proceeds to calculate the quantity of electricity involved. A metre of wire of this size weighs about

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44·5 grammes, and 6,700 calories are required to raise it to the fusing point of 1,200° C. A conductor of 5 sq. mm. section and 1 metre in length has an average resistance of ·01 Ω between 0° and 1,200°. A current C in time t will therefore develop in it

$$\cdot 24\ C^2 \times t \times \cdot 01 \text{ calories.}$$

Now it may be assumed that t varies between ·001 and ·03. Assuming the quantity of heat to be 6,700 calories, we get for C 52,000 and 9,200 respectively for the two values of t. The quantity of electricity would therefore be 52, or 270 coulombs, and would be sufficient to decompose 5 and 25 mgr. of water respectively. Or, taking another illustration, if the quantity of electricity could be stored and used to supply a 16 candle-power incandescent lamp, 35 and 7 of the flashes respectively would be required per hour. Palaz's investigations gave for a flash 28 coulombs.

The Telegraphs of Victoria.—The digest of the statistics of the Colony of Victoria for 1888, compiled by Mr. H. H. Hayter, the Government statistician, has recently been presented to Parliament; and it is there stated that telegraphic communication exists between 601 stations within the borders of Victoria. During the year 1888 the telegraph stations were increased by 86, the lines were extended by 79 miles, and the number of telegrams transmitted showed an increase of more than 20 per cent. over the previous year. A comparison of the two years is made by a table in the digest, giving the number of stations, lengths of line, and amount of business done, which were as follows:—

Year.	Number of stations.	Number of miles of line.	Number of telegraphs.		
			Paid.	Unpaid.	Total.
1888	601	4,194	2,653,000	90,938	2,743,938
1887	515	4,115	2,176,915	83,565	2,260,480
Inc.	86	79	476,085	7,373	484,458

In addition there were 231 miles of line in use as private wires and telephone lines.

An Electro-Pneumatic Railway Signalling System.—An automatic block system has recently been introduced on the Central Railroad of New Jersey, between Jersey City and Bergen Point. In the system adopted the signal arms are moved by the piston-rod of a single-acting pneumatic cylinder, the valves of which are controlled by an electric current. The arm is weighted to fly to "danger" if anything goes wrong with the apparatus. As a train enters a block it cuts the current off from the electro magnets operating the valves of the cylinders of both home and distant signals, which are accordingly both raised to the "danger" position. As the train passes into the next block the current round the distant signal magnet is re-established, and this signal then falls. The home signal, however, remains at "danger" until the train enters the next block but one, when it is lowered in the same way. These operations are carried out in the following way: The rails for one block are insulated from the rails in the preceding and following blocks, and the right and left-hand rails at the commencement are connected with the poles of a two-cell gravity battery. Between the other ends of the rails is inserted a relay, the armature of which, when no train is in the block, is held down by the current from the battery, and completes the circuit of the battery working the semaphore valves. As soon as the train enters the block it short-circuits the relay, which in turn interrupts the current, the semaphore circuit is broken, and the valves of the signals, being no longer held down, they move over, and the signals at the commencement of the block fly to "danger." As the train leaves the block the current is re-established through the relay, and the distant signal falls to "line clear." The home signal is, however, arranged to remain at "danger" till the train reaches the next block, when it is lowered in its turn. This system has been worked out by the Westinghouse Company.

The Kousmine Diffusion Battery.—The diffusion battery of M. Kousmine, which was shown at the recent Galvano-Plastic Exhibition at St. Petersburg, has been much used in Russia. By making use of the phenomenon of diffusion M. Kousmine has succeeded in overcoming the increase in internal resistance of the bichromate of potash battery due to the formation of crystals on the positive electrode. The positive carbon electrode consists of four strips attached to the lid of the battery. The negative zinc electrode consists of a circular grating, resting on the bottom of the battery. By means of a funnel a 15deg. Beaumé solution of sulphuric acid is introduced, until it just reaches the lower end of the carbon strips. A 6 to 7 per cent. solution of bichromate of potash is next introduced. The two liquids do not mix on account of the great difference in their densities. When the battery is short-circuited it is easy to see that chemical action only takes place close to the lower end of the carbon strips, which are gradually surrounded by a violet ring 2 or 3 millimetres deep. Above this region the bichromate solution retains its original colour. The bichromate solution being very weak, the chromic crystals dissolve as soon as they are formed, and the positive electrode is not covered by a deposit as in other batteries. The solution of these crystals, having a greater density than the surrounding liquid, falls to the bottom. The sulphate of zinc also falls to the bottom of the cell, causing more sulphuric acid to rise, A cell having the following dimensions was tested by a committee of experts at the Exhibition in question.:—Height 20 cms., diameter 15 cms., surface of zinc 176 sq. cms., bichromate solution 6 per cent., sulphuricacid 15deg. Baumé. The committee reported that after having been circuited for 8½ hours on an external resistance of ·32 ohms, and then left on open circuit for 10½ hours, the cell continued to work for 4½ hours, when the circuit was again closed, and that it gave during 13 hours 36 ampere-hours for an expenditure of 48 grammes of zinc.

The Epstein Method of Forming Storage Battery Plates.—The object aimed at in this method is to form the plates of a storage cell with greater rapidity than hitherto, without diminishing their durability or capacity. Lead plates of any shape suitable for use as electrodes are put into water rendered acidulated by the addition of about 1 per cent. of nitric acid. The plates are kept from coming in contact with each other, and the water is always kept up to the boiling point, the boiling being continued till the lead has assumed a dull grey appearance. The plates are then taken out of the water and dried in the air. This treatment produces a greyish yellow deposit of lead compounds which has the appearance of mildew. This deposit adheres very firmly, and is insoluble in the electrolyte used for the subsequent treatment in dilute sulphuric acid. In addition it has a great capacity for taking up the gases engendered in the formation process, so that the latter may proceed quickly, without the necessity of reversing the current. It is these "raw" plates, as they are called, from which the positives as well as the negatives are formed. In order to form positive electrodes a number of raw electrodes forming a group are put into the electrolyte, together with positive electrodes, that have to be transformed into negative electrodes. The raw electrodes that have to be formed into positive electrodes are then connected with the positive pole, and the intervening plates with the negative pole of a dynamo or battery. In the process of forming positive electrodes, the former greyish-yellow colour of the raw electrodes changes into a deep dark-brown, almost bluish-black hue, and the process is completed as soon as the electrodes have assumed that colour, and an abundant development of oxygen takes place. The oxygen of the peroxide of lead produced on the positive electrodes which are to be reduced to negatives is absorbed by the effect of the electric current, and the bodies are reduced on their surface to porous metallic lead. The process of forming negative electrodes is finished when the deep dark-brown or bluish-black colour of the positive electrodes used for the purpose has changed into a bluish-grey hue and an abundant development of hydrogen takes place. A few hours only are necessary to form a plate by this method, and the reversing of the current is unnecessary, so that in a very short space of time a great number of positive as well as of negative electrodes can be produced.

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MAGNETISM IN IRON AND OTHER METALS.*—XX.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 84.*)

§ 82. Dissipation of Energy by Reversals of Moderately Strong Magnetisation.—When the intensity of magnetisation at which reversal takes place is reduced, the energy dissipated is, of course, less than has been stated in § 81. Fig. 50 shows the effect of subjecting a piece of soft annealed iron wire to a graded series of reversals beginning with weak forces, and gradually increasing the force till the limits of H were ±75 C.-G.-S.† Parts of the curves relating to strong forces are

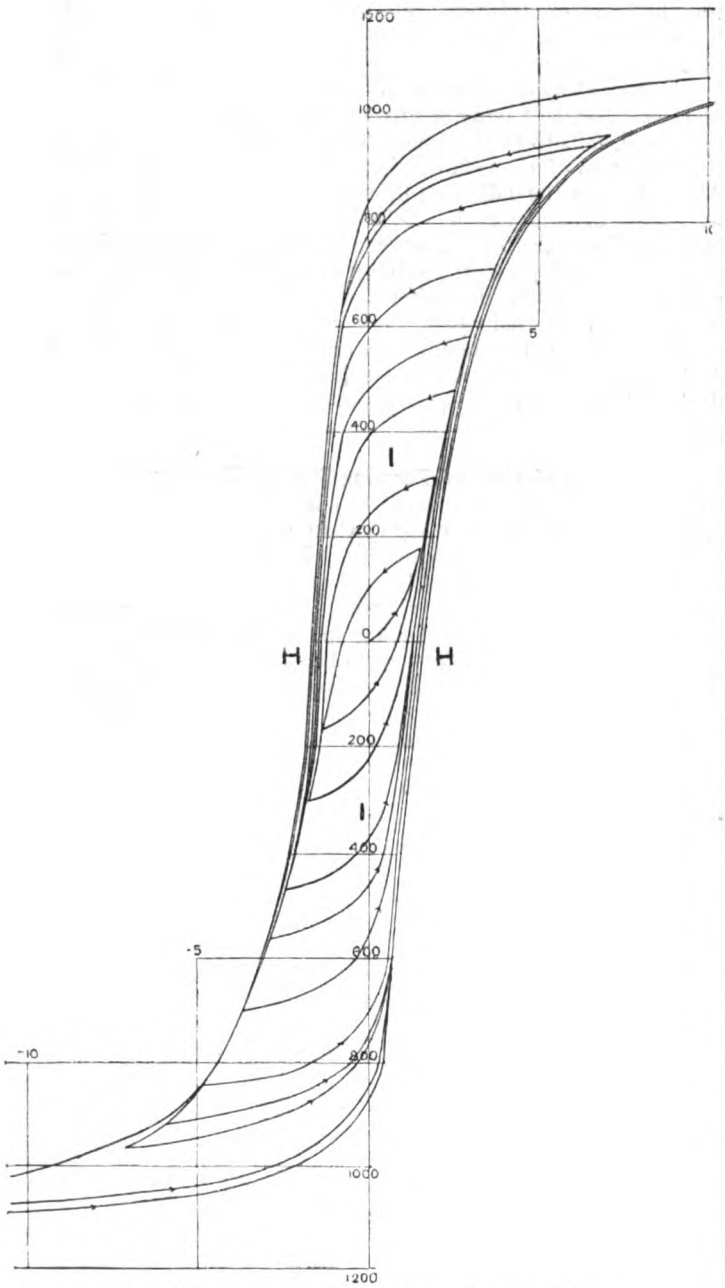

FIG. 50.—Graded cyclical magnetisations of soft iron.

omitted in the figure. The wire was 0·078cm. in diameter and 29cm. long, and was tested by the direct magnetometric method; between 300 and 400 observations of the relation of H to I were required to define the curves in the 10 successive processes of double reversal which are represented in the figure. In Table V. the numbers in the first, second and third column are the values of H, of B, and of I, between which the successive double reversals took place; the next column gives the energy dissipated per cycle in ergs per cubic centimetre, found by measuring the areas enclosed within the curves, and the last shows the rise of temperature which a complete cycle should produce.

These results are shown in Fig. 51 by plotting the measured values of $\int H\,dI$ in terms of the induction, B, at which each double reversal took place. It will be seen from the curve that the waste of energy increases rapidly as B is raised, which is a reason for avoiding high induction in the cores of transformers, and in the armatures of alternate-current dynamos. With low intensities of magnetism the waste is less than proportionally small. Table VI. gives numerical values taken from the curve of Fig. 51, along with the horse-power wasted per ton of iron, if 100 cycles (that is, 200 separate reversals) are completed per second.*

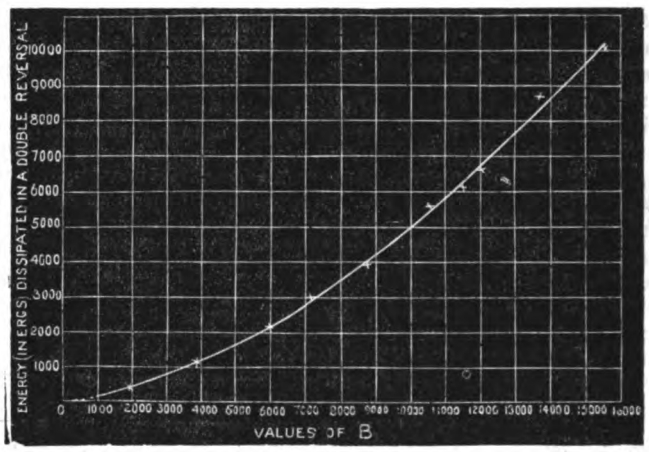

FIG. 51.—Dissipation of energy in soft iron through magnetic hysteresis in double reversals of magnetisation.

TABLE V.—*Graded Cyclic Magnetisations of Soft Iron.* (Fig. 50.)

H	B	I	$\int H\,dI$	Calculated rise of temperature.
			ergs.	deg. C.
1·50	1,974	167	410	0·000012
1·95	3,830	304	1,160	0·000033
2·56	5,950	473	2,190	0·000062
3·01	7,180	571	2,940	0·000083
3·76	8,790	699	3,990	0·000113
4·96	10,590	842	5,560	0·000158
6·62	11,480	913	6,160	0·000175
7·04	11,960	951	6,590	0·000187
26·5	13,720	1090	8,690	0·000247
75·2	15,560	1230	10,040	0·000285

TABLE VI.—*Dissipation of Energy by Double Reversals of Magnetism in Soft Iron.*

B	$\int H\,dI$ (ergs).	Horse-power wasted per ton assuming 100 cycles per second.
2,000	420	0·74
3,000	800	1·41
4,000	1,230	2·18
5,000	1,700	3·01
6,000	2,200	3·89
7,000	2,760	4·88
8,000	3,450	6·10
9,000	4,200	7·43
10,000	5,000	8·84
11,000	5,820	10·30
12,000	6,720	11·89
13,000	7,650	13·53
14,000	8,650	15·30
15,000	9,670	17·10

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† *Phil. Trans.*, 1885, p. 555.

* See also Mr. Kapp's Paper on "Alternate-Current Machinery" (*Min. Proc.* Inst. C.E., Feb., 1889), where a similar table is given, calculated from the same experiment.

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Fig. 52* shows the results of a corresponding experiment made with a specimen of annealed pianoforte steel wire. Here much the same features present themselves. When the magnetisation is feeble there is but little dissipation of energy, but as the range of I is extended the area of the loops increases fast.

Fig. 53† exhibits, in a different way, the results of these two experiments on iron and steel. The heating effect of a cycle (calculated from $\int H\,dI$) is shown in relation to the value of H which was reversed. At first the heating effect of reversal is much less in steel than in iron, with a given value of H, for its smaller susceptibility makes the whole magnetic change comparatively small in steel. But with stronger fields its greater coercive force begins to tell, and the heating effect becomes at last very much greater in steel than in iron.

§ 83. **Influence of Speed on Magnetic Hysteresis.**—Experiments are wanting to show whether the speed at which a cycle of magnetisation is performed has, in general, any material effect on the value of $\int H\,dI$. In certain cases speed is known to have an effect. In the next chapter results will be described which show that when bars of soft iron are subjected to a very small cyclic changes of H the corresponding magnetic changes depends very largely upon the speed at which H is varied. There does not appear to be anything like so serious a dependance on speed when the magnetic changes are considerable; but it is still doubtful to what extent the results given above, calculated as they

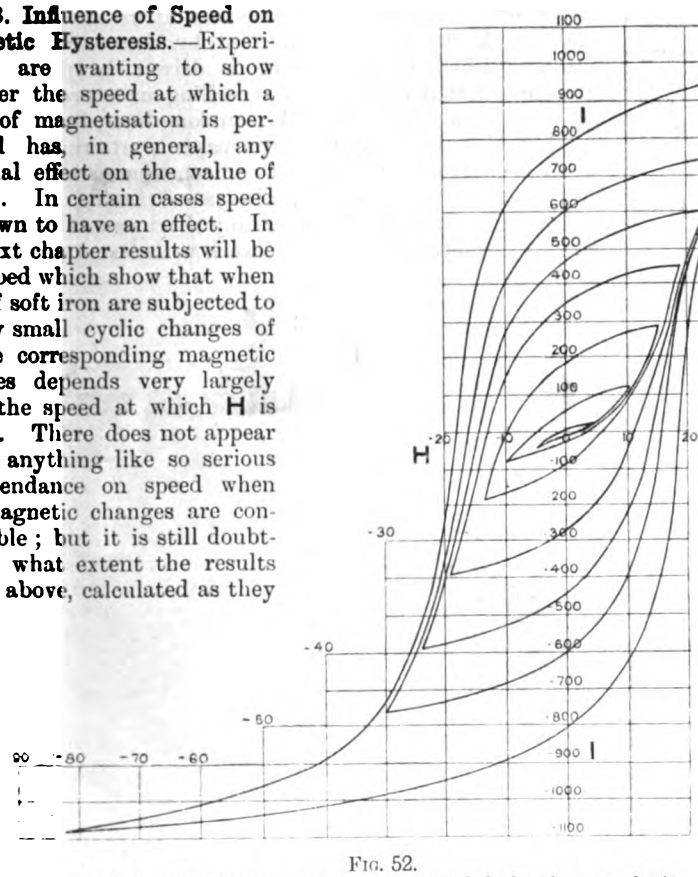

Fig. 52.
Graded cyclical magnetisations of an annealed pianoforte steel wire.

are from the observed relation of I to H when H is changed very slowly, are applicable when H is changed fast. With regard to small changes of magnetising forces, at least, soft iron exhibits what may be called magnetic viscosity—that is to say, the changes of magnetism follow somewhat sluggishly the changes of magnetising force, just as in the stretching and unstretching of a rod of india-rubber by applying and removing weights, the changes of length follow sluggishly the changes of load. If this property exists to any considerable degree in wide ranges of magnetic change, it may have the effect of causing $\int H\,dI$, in a quickly performed cycle, to have a value very different from the value observed in such experiments as have been described.

The whole question of magnetic viscosity is one of great practical interest. Probably it is to direct calorimetric measurements of the heat generated by magnetic reversals that we may most hopefully look for its solution, but direct calorimetric measurements present a good deal of difficulty. They have been made by more than one observer, but the experiments hitherto carried out cannot be said to settle the question raised above. Warburg‡ and Hönig, experimenting with bundles of fine wires (to get rid of Foucault currents), found that the heating effect of reversals, as measured in a calorimeter, was about two-thirds of the value of $\int H\,dI$, as calculated from magnetic observations in slow cycles. Tanakadaté,* using a multiple ring of cotton-covered soft-iron wire, and measuring the heat developed in it by reversals, by noting the rise in temperature of a thermo-electric junction placed under the magnetising coil, found the heating effect of quick cycles to be equivalent to about 80 per cent. of the slow-cycle value of $\int H\,dI$. He observed, further, that the heating effect was practically independent of the frequency of the reversals when that was varied between the limits of 28 and 400 cycles per second. A chief difficulty in observations of this class is to determine what is the actual value which H reaches during rapid alternations of the magnetising current.

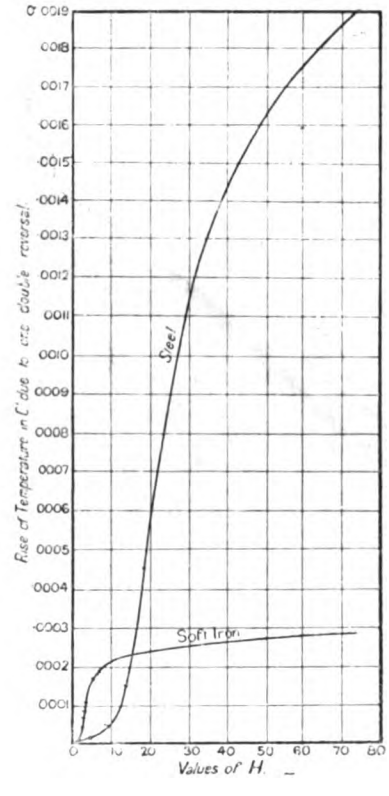

Fig. 53.—Heating effect of reversals of magnetising force in iron and steel.

Though these results are subject to some uncertainty, they concur in making it probable that, for a given value of alternating H, the range of magnetisation is less in quick alternations than in static experiments (where the reversal goes on slowly or by steps with pauses between), and hence that the dissipation of energy in a quick cycle is less on account of this diminished range of magnetic change.

(To be continued.)

Royal Society.—The following were amongst the Papers down for reading yesterday at the Royal Society:—Prof. Rücker, F.R.S.: "On the Relation between the Magnetic Permeability of Rocks and Regional Magnetic Disturbances." H. Wilde, F.R.S.: "On the Causes of the Phenomena of Terrestrial Magnetism, and on some Electro-Mechanism for exhibiting the Secular Changes in its Horizontal and Vertical Components."

* *Phil. Trans.* 1885, p. 556.

† Copied from a Paper by A. Tanakadaté "On the Thermal Effect due to Reversals of Magnetisation in Soft Iron," *Phil. Mag.*, Sept., 1889.

‡ Wied. *Ann.*, 1883, Vol. XX., p. 814.

* *Phil. Mag.*, Sept., 1889.

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THE EDINBURGH EXHIBITION.—I.

The Eastern Telegraph Company's Exhibit.

The exhibit of the Eastern Telegraph Company at Edinburgh is one of the most complete and interesting in the Exhibition, comprising, as it does, examples of the various types of apparatus employed in cable work. A prominent feature of this exhibit are two of Sir William Thomson's syphon recorders. One of these instruments is the second of the kind ever made; and the other is a modern instrument, containing all the latest improvements. The special feature of these, as will be well known to many of our readers, consists of a very fine glass syphon, which brings the ink down from a small ink-well nearly on to the centre of a running slip of paper, so that if it quite touched it would normally trace a straight line. To produce signals the point of the syphon is deflected either to the left or right by the action of the current on a small coil suspended between the poles of a very powerful magnet, the coil being attached to the syphon by means of a very fine fibre. As stated above, the syphon brings the ink very *nearly*, but not quite, on to the paper—it would not do to allow the point of the syphon to quite touch the paper, or the friction would be too great for the received current to overcome. Means have therefore to be provided to spurt the ink from the point of the syphon on to the paper. Formerly this was done by electrifying the ink with a static charge, produced and maintained by the familiar "mouse mill" apparatus and a small induction machine, and so causing the ink to jump off the point of the syphon on to the paper which was connected to earth. This method had its drawbacks, especially in damp weather, when it was found difficult to properly maintain the electrification. However, by keeping in constant agitation the cradle from which the syphon is suspended, the ink can be mechanically shaken off the point of the syphon on to the paper in sufficiently small drops, and the electrification therefore dispensed with. This improvement was devised by Messrs. Ash and Tuck, superintendents in the service of the Eastern Telegraph Company, and is shown working on the new instrument exhibited, which also has powerful permanent magnets in place of the electro-magnets previously employed. The means adopted for producing the vibration consists of a small electric arrangement, similar to a trembling bell movement; but made in a neat form, capable of being attached to the syphon suspension frame of the instrument, and having an adjustable weight, by which the rate of the vibration can be so set as to best coincide with the particular rate at which the globules of ink most readily form at the point of the particular syphon in use.

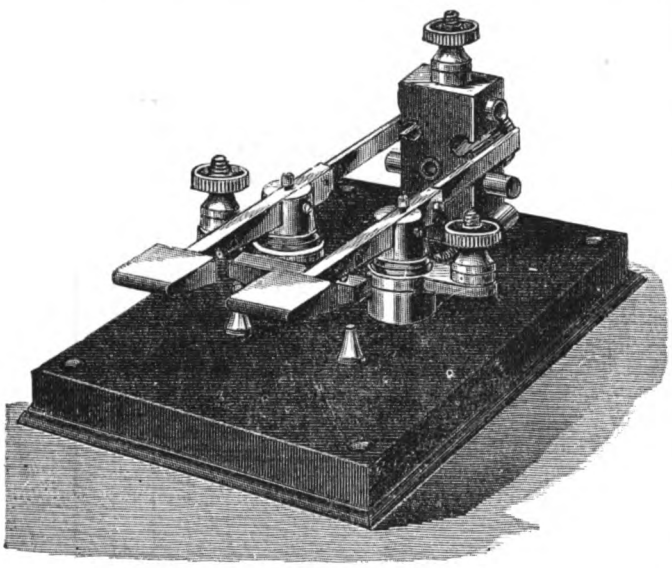

Fig. 1.—Saunders' Reversing Key.

Mr. H. A. C. Saunders, chief electrician to the Company, shows a reversing and a capacity key. These keys (Figs. 1 and 2) have been specially designed for testing purposes on board cable repairing ships and at cable stations. The weak points in the construction of most previous patterns have been avoided in these by the following improvements. Stout brass bars replace the flimsy strips of sheet metal hitherto employed; uncertain contact is prevented by the substitution of broad rubbing surfaces of gold-copper alloy and platinum; cams and similar devices for holding down the levers of the keys (always fruitful sources of error and trouble) are rendered entirely unnecessary by the absence of springs. An insulated rocking beam, a device due to Mr. Saunders, is pivoted beneath the front parts of the levers, so that the depression of the one lever causes the elevation of the other; thus, in the reversing key rendering any short-circuiting impossible, and in the capacity key enabling the discharge of cable and condenser to be rapidly effected when taking Thomson's capacity test in the manner adopted by Dr. Muirhead.

Another exhibit, which is to be seen at work, consists of an automatic Morse apparatus, devised by Messrs. Saunders and Brown, on which the paper strip is driven electrically by the same current that operates the signalling armature. This current is supplemented, if need be, on long lines, by a local battery, but in such a way that the paper starts running immediately the sender at the distant end commences operating, and stops shortly after he ceases, always continuing to run long enough, however, to bridge over any short pauses in his sending. The complication of clockwork with its attendant evil, winding, is therefore dispensed with entirely; and, providing a sufficient supply of paper slip is left in the drawer, the instrument is capable of receiving a message in the absence of a receiving clerk, a few spare movements of the sending key at the transmitting station at the commencement of a message being all that is necessary to start the paper slip at the receiving instrument.

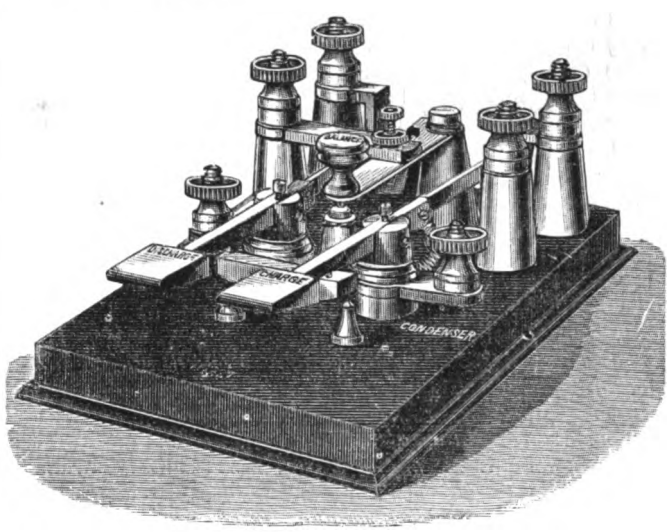

Fig. 2.—Saunders' Capacity Key.

There is also on exhibition a well-finished model of the improved form of bow gear for cable operations, as made for the Company's steamship "John Pender," and designed by Mr. Isaac, the Company's superintendent engineer. This arrangement is to supersede the old system of carrying the bow sheaves on wrought iron girders, which occupy considerable width, and in the latest cable ships has necessitated the spreading out of the bow. This, when the vessel pitches, causes inconvenience, and at times the starting of the butts of the plating. The improved arrangement is made entirely in cast steel, and enables the bow gear to be fitted into a cut-water bow, and at the same time preserves the handsome outlines of the head. The weight of the new gear, with three sheaves, is 4 tons 9 cwt., against 7 tons 5 cwt. for the old gear, with only two sheaves. This saving of top weight is also a point in favour of the ship. The present model and the actual bow gear for the vessel have been made by Messrs. Johnson and Phillips. Another exhibit is a model of Sherlock and Pattison's ship's tell-tale telegraph,

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designed so as to give a warning signal in the event of a ship's engineer mistaking, or from any cause improperly executing, an order given on the ordinary ship's engine-room telegraph. This consists of an arrangement having a mechanical connection directly with the engines' reversing gear, and working in conjunction with the pointer of the ordinary ship's telegraph in such way that an electric contact is closed whenever the position of the reversing gear does not coincide with that which it should occupy to properly carry out the order last given. When the proper coincidence of the reversing gear with the telegraph hand is established, this contact is broken. It is needless to add that a battery and electric bell, or other means of producing a sound, is joined up in circuit with the above-mentioned contact, and thus serves to give a continuous warning to the engineer; and also, if so desired, to the captain as long as any order from any cause remains unexecuted or improperly carried out.

There are also working two call points and a station indicator, of Saunders and Brown's fire alarm telegraph system, as used by the Metropolitan Fire Brigade in the streets of London. This apparatus embodies a number of practical details found necessary in the actual working of fire alarm telegraphs. Thus it gives an effective call, irrespective of an excited caller's action with the knob, after he has once pulled. It keeps the line under continual test for contacts, &c., but makes a distinction between rings arising from such causes and real calls from the call point. It enables replies to be sent in answer to the calls and conventional signals to be sent by the firemen, both from and to the posts without requiring any batteries in the posts. An additional feature of this system, due to Mr. Lewis, General Manager of the Western Counties and South Wales Telephone Company, consists of a loud ringing alarm bell placed within the post or immediately above the wall box, out of reach of the person giving the alarm. This bell is rung immediately the knob is pulled, and not only acts as a powerful fire alarm notice to the police or passers by in the road or street, but leads to the detection of persons giving false alarms. The knowledge of this acts as a great deterrent upon mischievously inclined persons.

The remaining exhibits comprise a model of the Company's twin screw cable steamship, "Mirror," showing all the cable machinery; a large and accurately drawn map, showing the position of the Company's cables and land line connections throughout the world; and a Saunders' lightning guard (see *The Electrician*, April 27, 1888).

The London and North-Western Railway Company's Exhibit

This Company show a large number of electrical appliances employed in railway working, and the following is a brief description of the more important of these exhibits:—Persons conversant with the regulation of traffic on important lines of railway are well aware of the waste of time that occurs when a man from the station has to accompany a train with a key to unlock a siding; and amongst the apparatus displayed by this Company is an electric locking system, devised by Mr. Fletcher, their telegraph engineer, to do away with this delay, and electrically control sidings, &c., situated at too great a distance to be worked in the ordinary way with rod and lever. In the normal state of the arrangement the signals at the signal-box are unlocked and those at siding are locked, this state of affairs being maintained by the constant flow of current through electro-magnets. If a train has to call at the siding the signalman, by the insertion of a common carriage key into his instrument (provided always that the signals are at "danger") disconnects the circuit, with the result that the signals are locked and the lever at the siding unlocked. When the train is ready to proceed forward the reverse process is effected. Another piece of apparatus is the "Tell-tale" instrument for permissive working. The instrument is somewhat similar to the ordinary 3-wire instrument, with the addition of a commutator fitted with a revolving disc, lettered "Line closed," "Line clear," "Train on line," and Nos. "2" to "6" on the remaining sections of the disc. As additional trains are admitted into the section, a corresponding portion of the disc is brought forward, and as the trains pass out of the section the same disc is moved back, section by section, until the line is clear. A constant reminder is thus afforded to the signalman of the number of trains there are in his section. Some electric fog horns and detonators are also shown. The starting and stopping of the apparatus is caused by the passing trains actuating treadles, not by actual contact, but a depression of the permanent way; the fog horn is worked by a small motor, attached to a bellows arrangement which supplies the required pressure of air to blow the horn. The electric detonator acts by means of an electro-magnet and armature, and is capable of discharging 50 fog cartridges without attention. While a train is in the neighbourhood of the "contacts" the apparatus continues in action, but the signalman has the power to put it out of circuit at any time. One of the most important matters in connection with a railway is the outdoor semaphore signals, on the maintenance of which in a state of efficiency the safe and punctual running of trains in a very great measure depends. Some of these signals have perforce to be placed out of sight of the signalman, and it is necessary that he should have some means of ascertaining the state of the signals. Until recently electric repeaters provided for this purpose have only showed signal *on* by current and *off* by gravity. The form of instrument, due to Mr. Fletcher, now in use on the London and North-Western Company's system, shows:—Signal *on* by current, signal *off* by current, signal *wrong* by gravity, light *in* by current, light *out* by current; and these five indications are given by means of one wire only. The watchman's tell-tale apparatus, adopted by the London and North-Western Company in all their large goods yards, is briefly as follows:—An intermediate indicator is fixed wherever it is necessary for the watchman to visit, and at each of these places the circuit is broken, so that the watchman has to turn a key in each indicator to make the circuit good. At the end of the circuit there is a terminal indicator, and the first result of the turning of the key sends a positive current to a clock, recording the time of the completion of the journey. The key, however, cannot be withdrawn without turning the commutator completely round, resulting in the reversing of the current, which causes the whole of the "bridging" pieces in the intermediate indicators to fly off, leaving the circuit broken down, and compelling the watchman to go round again and perform the same manipulation at each point before he can make another record on the paper at the clock.

Exhibit of Woodhouse and Rawson United.

In addition to a large display of measuring instruments, switches, and cut-outs, this firm shows one of Commander Percy Scott's flash-signalling lanterns, which has been designed with a view to enable flash signals to be sent on the Morse system with greater rapidity than has heretofore been possible, and from a point where the present mechanical arrangement of shutter could not well be employed. The lamp is surrounded by a number of vertical shutters, pivoted above and below, and engaging by means of short arms or toothed wheels a central wheel. The motion of the latter is produced by an electro-magnet action against the force of springs. When the magnet is energised a rapid but short movement of the wheel takes place, opening the shutters for a longer or shorter period as desired, and producing thereby longer or shorter flashes of light. The action of the springs carries the wheel back to its original position as soon as the current is broken in the electro-magnet. The electrical circuits are arranged in a special manner, with the view of avoiding running the lamp at full incandescence during the time the shutters are closed. The magnet coils are therefore put in circuit with the lamp, the resistance of the former acting so as to dull the incandescence, but only to such a point as will allow the thick filament necessary for the 100 candle-power lamp employed to rise to its full incandescence during the period of the shortest flash which may be found possible to use in practical working. In order to further reduce the strain put upon the lamp by the heat developed during continuous running a special switch is employed. The handle of the switch is hinged in such a way that under normal conditions a strong spring is pulling upon the end of it and breaks the main circuit to the lantern. In order to commence signalling it is necessary to pull down

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the handle against the force of the spring. This completes the circuit to the lantern, and a further depression similarly to a telegraph key operates the shutters. The contacts are so arranged that in the act of opening the shutters the lamp and magnet circuits are momentarily in shunt to one another; and as the E.M.F. absorbed by the magnet coils is only 8 volts, the amount of sparking during signalling is very small. Extra contacts are attached to the switch to enable a Morse instrument to be added whereby the signals may be automatically recorded in the same way as in telegraphy. The lantern has been in work for several months on board H.M.S. Northumberland. It is hoped that by means of this lantern it may be possible to attain to such speed in flash signalling that the two services may be able to interpret each other's signals, which at present is found to be impossible owing to the widely different rates at which the signals are sent by the two.

Another exhibit of this firm is Horn's electric tachometer for indicating directly the speed of a rotating shaft. The action of this instrument, as is well known, is based upon the fact that electric currents are set up in a copper disc when it is rotated in a magnetic field. The instrument comprises a powerful horse-shoe magnet and an armature which consists of a ring of copper mounted on a spindle, which is driven by a band from the shaft, the speed of which is to be measured. Within the copper ring there is a soft iron bar. This bar is constrained by the magnet to take up an axial position between its poles, and to form a direct path for the lines of force between the poles; but immediately the copper ring commences to revolve the currents in the copper tend to rotate the bar on its axis, and thus it moves from its horizontal position until it finds a point at which the influence of the magnet is balanced by that of the Foucault currents. An arm on the spindle carries

Horn's Electric Tachometer.

a curved rack, which gears with a pinion on the index spindle, and thus the movement of the bar is greatly magnified upon the dial. The accuracy of the indications is not dependent (within limits) on the strength of the magnet, since the two forces acting upon the bar vary together. Several specimens of a new insulating material (the main constituent of which is Portland cement), suitable for the bases of switches and other work requiring high insulating properties, coupled with uninflammability, are shown by this firm.

Messrs. Carrick and Ritchie, hydraulic engineers, in addition to a number of their well-known Waverley turbines, show a Girard turbine, specially made for high falls up to 300ft. or 400ft. To illustrate what can be done by applying the ordinary town water supply to produce power, a small jet motor is fixed, and is shown at work driving a dynamo. The water is taken from the main pipe in the Exhibition, where there is a pressure of about 50lb. to the square inch. The water, after being used in the motor, is returned to a large tank, and used for feeding the boilers. This motor uses the water in an economical manner, as it has two jets, both of which can be used when all the power is required, and one only when less than the full power is wanted. By this means the pressure of the water is not lessened by being drawn through a partly-closed orifice, but is allowed to pass into the machine with the full pressure in the pipe due to the head. Riveted steel pipes, which are fast superseding cast-iron ones, for the conveyance of water to turbines and for other purposes, are also shown. The Magnolia Anti-Friction Metal Company of Great Britain exhibit a number of bearings made of this metal, which have come successfully through a variety of severe practical tests. Messrs. Faraday and Sons' exhibit consists of a fine display of the artistic electric light fittings, for which their name is so well known. The most noteworthy are the new shrine lamp in pierced and repoussé metal, resembling the delicate Venetian work of the seventeenth century; bronze and silver from models of the Rénaissance bearing electric torches or cressets, and standards or tripods; and Sir David Salomons' adjustable reflecting pendant and "universal" wall plug Messrs. Cox-Walkers make a good show of their specialties. One of their well-known watchmen's electric tell-tales for 24 stations has been connected to stations all over the buildings, and is now in regular use by the watchmen. This firm have also provided and erected for the use of the Exhibition authorities 24 fire-alarm call-boxes, and seven or eight indicators fixed in various suitable positions, with one main one in the central fire station. Anyone pulling a knob at any of the alarm cases drops an indicator at all the places, showing where the alarm is given from, and rings a bell at the alarm case and large bells in numerous parts of the buildings at the same moment. Magneto keys or tappers and sounders for telegraphing the Morse alphabet without batteries, which should be very valuable for military and similar purposes, are also shown by this firm, who have also fitted up the electric signalling arrangements for the ship railway.

(To be continued.)

ELECTRICITY IN THE NAVY.*

BY GILBERT WILKES, U. S. NAVY.

I have taken as my title "Electricity in the Navy," and shall give in my Paper the general conclusions derived from five years' more or less intimate connection with the application of electricity in our naval service. The electrical engineer has little to do with the placing of the dynamo room, which is of necessity governed by the arrangement of the ship as a fighting machine. I shall, therefore, merely consider the power and apparatus of the plant, commencing with the engines. Both in this country and abroad compound condensing engines have been used, some having separate condensers, some exhausting into the main condensers of the ship; but the preference seems to be in favour of simple double acting, high-speed engines, the reason being that the power used for electrical purposes is so small in proportion to that of the main engines of the ship (only about an average of 1 per cent.) that the saving does not pay for the additional complication and cost. However, with a given plant, the engine should be constructed to allow little variation of speed under large changes of steam pressure, in order to take advantage of the main condenser when possible. In our service both horizontal and vertical engines are now in use, the preference in some cases being the result of the shape of the available space. No data have yet been obtained as to the most economical type, but both are doing good service, the mishaps having been due to accident. Of late years all of the engines put in for electric lighting have been high speed, the largest of about twenty-five horse-power and running at 400 revolutions.

The important points in the consideration of a marine dynamo are:

First.—It should be direct driven. The reasons are obvious, as not only is the space taken up by the belting valuable, but in a sea way the danger of running belts must be considered, especially when it is taken into account that naval vessels are fighting machines, and the possibility of accidents must be reduced to a minimum.

Second.—It should be compact. This is a natural extension of the above. Even now it is difficult to find room for all the machinery, stores and ammunition, besides providing room for berthing the crew on a modern man-of-war.

Third.—It should be free from liability to injury by salt water, and not too subject to mechanical damages.

In this respect there remains room for considerable improvement, the latest dynamos now better filling this requirement than did the old "L" machine on the Trenton in 1883, the first dynamo afloat in our navy, and which ended its useful career in the great storm at Samoa last year, when it ran until the water had put out the fires under the boilers. On board ship salt water and damp air get

* A Paper read before the American Institute of Electrical Engineers, New York, May 20 1890.

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everywhere, and within the last year a number of cases of slight burn-out have occurred in armatures, which, when installed, measured high in the hundreds of thousands of ohms insulation. The dynamo should not be easily harmed. The dynamo room is now always low down in the ship, under the protective deck (if there is one), and when the light is not in use the room is very dark, rendering careful inspection difficult.

Fourth.—The dynamo should have small effect upon the compasses. This point has received little attention, though it is a matter of great importance, as the effect on many vessels is so large that, in order to work up the day's run, it is necessary to know the hours during which the dynamos have been in operation. Complete deviation tables are, therefore, necessary for the two cases. In different types of dynamos the effect with a twenty horse-power machine, at a distance of twelve feet, will vary from less than one-twentieth of the horizontal component of the earth's magnetism to several times the strength of the horizontal component. The latter is, unfortunately, rather the rule than the exception, and, in consequence, the position of the dynamo room has to be well borne in mind in locating the standard compass.

Fifth.—It should be easy in running and require but little attention. The machine should be non-sparking, under constant load, and also be able to stand sudden large changes of load with little sparking. This is necessitated by the fact that the dynamos now supplied for incandescent lighting are also used for search light work, and the conditions are aggravated by most of the search lights having hand regulation only. Thus, with a 200 ampere machine, not only are from 50 to 100 amperes thrown suddenly on and off, but, at the moment that the operator at the projector brings the carbons together, the dynamo is suddenly called upon to deliver over three-fourths of its total capacity.

Sixth.—It should be efficient and run cool, the former in order to avoid the waste of energy and a corresponding amount of the coal supply, and also in order to avoid overheating. The dynamo rooms on ship board are, at best, warm, notwithstanding the motor fans, which are now usually supplied, and thus the safe limit of extra heating is reduced. At the same time, consideration for the attendants requires that the cramped space be kept as cool as possible.

Seventh.—The dynamo should maintain a constant potential at all loads. This is, of course, accomplished by compounding, and, as there is only about 3 per cent. drop, it is usual to compound exactly, or to only overcompound enough to allow for the decrease in the engine's speed with load.

Eighth.—The dynamo should be light. The reasons are obvious, but it is considered last, because usually a careful study of the materials, and arrangement of the plant, can accomplish more towards reducing the total weight than the strict adherence to a specification of watts per pound of dynamo. Thus, consider the difference between the weight of a 40 horse-power ship plant on a five watts per pound specification and upon a four watts specification. Two 200 ampere, 80 volt dynamos, with their share of the bed-plates, will only weigh about 7,500 pounds. Twenty per cent. of this will be 1,500 pounds, an amount a large portion of which can really be saved in some cases by more careful attention to the amount of wire and moulding employed.

Naturally no one dynamo can best fill all of these conditions, and while the order in which they are above arranged will usually approximate to their relative importance, special cases arise which demand a re-arrangement. Thus, on torpedo boats, the most important quality is small size. With this in view, numerous devices have been placed upon the market and faithfully tried, but none have to my knowledge proved satisfactory. The requirements of high efficiency, low speed and low heating, all give way in this class of dynamo to the necessity of compactness and light weight. Good results were hoped for from the Parsons turbo-electric generator, but experience at Newport demonstrated that the turbine was so inefficient in its consumption of steam as to place its use out of the question. There is as yet no apparatus to satisfactorily fill this want. Up to the present all of our ship plants contain two or more similar sets, each composed of an engine and one direct driven dynamo. The larger of these are of 200 amperes capacity; a very convenient unit, but one which can be doubled in capacity with advantage in ships which are not light below decks and which are likely to soon have extensive motor application; for example, vessels of the monitor type. The voltage in use in the navy is 80 volts, this having been fixed upon as a mean between the most efficient pressure for the incandescent system and the voltage necessary for the search lights, to which current is supplied by the regular service machines. The incandescent lamps have given excellent results as to life from the very start, owing in great measure to the fact that low efficiency lamps are always used, nothing more economical than four watts per candle-power being usually required. Search lights of 50 volts and from 50 amperes up are used, two or more being supplied, according to the size of the ship. Some of these are imported, others are made in this country. The two-wire system has always been used in the naval service, the ship never being allowed to form the return circuit. On account of the present beginning of motor work on board ship and the future developments confidently looked for, the direct current has always been used. Motors have thus far been used only in driving small fans up to one-half horse power, for hoists, and in one case a motor has been used for training one of the large guns—on the "Chicago." There are numerous small engines about a man-of-war, varying from 1 to 50 horse-power. Some of the smaller ones might even now be replaced with advantage by electric motors; but it must be proved in each case; that the motor not only does the duty as well as the engine it replaces, but also that it and any increase necessary in the generating plant take up less room and weigh less than the engine and its piping. This, of course, will always be the case where very small engines are replaced, and as the tendency is to increase the capacity of the dynamo plant, it may not be long before motors may look for a larger field on board ship.

All circuits are water tight from dynamo to point of distribution, the cut-outs having stuffing boxes through which the lead-covered wires enter. Even the switches and attachment plugs for portables are required, in certain places, to be water tight.

One electrical application that presents many advantages on board a man-of-war, especially when on a foreign station, is electrical welding. However, when it is introduced on ship board, the pressure of the generator should be reduced to 80 volts, in order that in case of emergency it might be used for lighting purposes, while the welders should have several sets of adjustable clamps. Welding machines have not yet been actually used on ship board, but it is to be hoped that their introduction is a development of the near future. They cannot supplant any of the existing dynamos, owing to the necessity of motors, but must come in to occupy a place of their own, to almost entirely supplant the ship's forge and add to the general useful equipment.

Thus the man-of-war is the proper field for nearly every form of application of electricity, and when the storage battery becomes more suited to the service there required, there is no doubt that it too will come in for its proper share of usefulness.

As to the naval work on shore in the electrical field, little need be said, as the practice at naval stations must be similar to that in ordinary commercial work. However, a navy yard is an ideal place for the erection of a central station for light and power. The streets must be lighted; closely grouped about the station are offices and large shops needing light in the dark afternoons, and power for motor work; then in an outer approximate semi-circle lie the officers' quarters; finally, there are anchor chains to be welded, boiler tubes to be repaired, and numerous other similar operations which can be better accomplished by the welder than by any other known means. This in an ideal plant will call for arc lights, incandescent lights, constant potential motors, a welding generator and welders. The complete combination will probably not be realised at any one place within several years, but a good beginning has been made in the arc light plant recently installed for outside and shop lighting at the Washington Navy Yard, and the progressive plan adopted by the Department leads us to hope that the shore stations will rapidly receive the benefits already enjoyed on ship board. Owing to the usually close grouping of the buildings and to the demand for motors, it is probable that only in exceptional cases will the alternating current be used extensively. Good use is already being made of small motors for drilling purposes at the New York Navy Yard, where several are in constant operation, having driven out the portable steam engine, counter-shafting and belting.

The applications of electricity in the navy have always been on the increase, and any one who has served one cruise with oil lamps and one with electric lights and motors will understand the favour in which the increasing use of electricity is held by the naval man.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, June 20th.

PHYSICAL SOCIETY.

5 p.m. Papers to be read: "The Stretching of Liquids." By Prof. A. W. WORTHINGTON. "The Measurement of Electro-Magnetic Radiation." By C. V. BOYS, A. E. BRISCOE and W. WATSON. "Notes on Secondary Batteries." By Dr. GLADSTONE and W. HIBBERT.

FRIDAY, June 27th.

SOCIETY OF ARTS.

9 p.m. Conversazione at Natural History Museum, South Kensington.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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THE ABUSE OF PATENTS.

Rumour of a very authoritative sort is rife that before the year is out there will be a renewal of those judicial combats which in the past have proved so disastrous to the progress of the electrical industries. We say "disastrous" advisedly, because few circumstances could be more prejudicial to the welfare of the industry as a whole than that entire branches should fall into the hands of monopolists who use their position to crush out all progress in hands other than their own. The state of telephony in this country is a standing witness to the paralysis that accompanies the establishment of an unwieldy monopoly. A legal terrorism has been established over small traders, out of whom no judicial decisions can ever efface the sense that they have a moral right to sell and use an invention which, like the microphone of Prof. HUGHES, was given to the world free of all patent-rights or restrictions. Following hard on the heels of the telephone litigation came that on the incandescent lamp—resulting in an equally disastrous issue. A single word in a single claim—a word which not even the patentee attempts to define—a word which has been legally twisted to cover things undreamt of at the date when it was written, bars the way to the progress of an entire industry, and establishes a monopoly of manufacture for the assignees of an inventor whose exceeding cleverness in inventing new names for old things has been thus twice legally established. To use a patent in this manner in monopolising a branch of industry for the benefit of a single firm or company which contributed nothing whatever to the preliminary stages of its progress is a flagrant misuse of the forms of law,

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and one which public opinion will not in future permit to go unchallenged. The so-called "fundamental" patent, or "blanket" patent, as our American cousins call it, covering the ground of a whole industry, is a moral impossibility. As a fact, inventions do not start full-fledged from the brain of a single man of genius; and the fundamental character of a claim in a patent specification can usually be only established by reading into its words a meaning which originally it was never intended that those words should possess. We cannot forget how ten years ago an attempt was made—happily an abortive one—to secure in this country a monopoly of dynamo machines for the company owning the patent of M. GRAMME, on the ground that, though GRAMME's claim was only for a particular way of winding wire on a ring armature so as to cover its surface all over, there were no commercial dynamos before GRAMME's. Neither can we forget how the Cheesborough patent has been legally converted into a claim for the flashing process; nor how the monopoly of gas engines was sustained, to the detriment of the industry, in claiming for a single firm the sole right to use the cycle of operations invented by DE ROCHAS fourteen years before OTTO's rediscovery of it.

Fortunately for the electrical industry, two recent cases have done much to check the scramble for judicial monopolies. The claim for the monopoly of the compound-winding of dynamos in the name of BRUSH, which was for long unchallenged, received last year a rude shock in the Scottish Law Courts. As the appeal in this case is *sub judice*, we must not comment on the matter further than to remark that in this instance the attitude of the holders of the English patents was far more liberal than in some of the cases previously referred to; inasmuch as the BRUSH COMPANY was contented with a moderate royalty, and did not attempt to secure to themselves a monopoly of manufacture. The other case is furnished by the action about the Gaulard-Gibbs patent for secondary generators: which patent was put forward as ground for a fundamental claim to the entire system of electric distribution by induction coils, but collapsed when the action was tried.

Some of the rumours now rife relate to an obscure patent which—so report says—is now being trimmed into shape so as to afford a legal claim to the entire use of closed-circuit transformers for central-station lighting. Other rumours affirm that the Edison "feeder" patent has been exhumed—one of the forty or fifty patents relating to electric lighting from the same hand—for a similar exclusive purpose. It is alleged that a legal disclaimer is now being prepared and presented to the Patent Office, which, if granted, will, in the opinion of experts, give to the owners of the patent the exclusive right to the modern system of using on a lighting system feeders which are not the ordinary mains. Another rumour, which, if less precise is more persistent, alleges that the EDISON-SWAN COMPANY is about to claim the sole right to use the cut-out devices which are a necessary part (owing to fire insurance rules) of every installation. Lastly, we have the remarkable *pronunciamiento*, published in the name of the LANE-FOX ELECTRIC COMPANY, breathing out, metaphorically, fire and sword against all who use accumulators with their electric lights, unless they are willing to tax themselves to the tune of one-eighth of the highest price at which electric energy may be charged in a public supply.

Against all such schemes for hampering the electrical industry for the benefit of monopolists a firm stand has been taken by the voluntary association in mutual self-defence of representatives of all the chief companies now holding Provisional Orders for the public supply of electric light and power within the metropolitan area. It could not be expected that important bodies like these could leave the fight against monopolies to the isolated action of small firms or single-handed defendants, as happened so disastrously in the litigation about the telephone and the incandescent lamp. Those who in their haste to get rich forget the old adage live and let live, will now find a wholesome corrective to their proceedings. No reign of terror can be established over the manufacture of induction-coils, the use of accumulators, or the employment of safety-fuses. If the monopolists endeavour to grab these things and saddle the industry with new disabilities, they will find the whole industry rising up to oppose them in the law courts. Blanket-patents are undoubtedly admirable for the owners—and for the lawyers: but they are essentially unjust, and the electrical industry will not readily consent to allow any more of them to bar the way to progress.

REVIEWS.

Electrical Engineering for Electric Light Artisans and Students.—By W. SLINGO and A. BROOKER. (London: Longmans Green, and Co.)

Of text books dealing in a more or less satisfactory manner with the elements of electricity and magnetism we have enough and to spare; and the supply of treatises on particular branches of electrical engineering, such as land line and submarine telegraphy, telephony, dynamo design, transmission of power, and alternate-current machinery, is also fully equal to the demand. But the student who, having mastered the initial difficulties of the science, is desirous of obtaining an accurate general notion of its practical applications, has hitherto been without a suitable work. The volume under consideration may, however, be fairly held to meet this want. The style is simple, and the explanations of electric and magnetic phenomena are clear and accurate. The authors have, moreover, taken great pains to keep their work well up to date, and to present things in something like their true proportions. Their readers are not treated, for instance, to pages of description of various palæozoic magneto-machines, nor are they in danger of rising from the perusal of the chapters on dynamos with the firm conviction that Lontin's dynamo and the Mordey alternator compete on about equal terms for the public favour. The book is one which is likely to prove of great value to a large class of readers.

The work contains seventeen chapters, the first two of which are devoted to a brief consideration of elementary principles. Chapter III. deals with primary batteries, and chapters IV.—VI. with electrical measurements and measuring instruments; the latest and most generally used apparatus being alone described. Chapter VII. treats of electro-magnets and electro-magnetic induction. We may remark in passing that the authors appear to hold by the old idea that the introduction of an iron core into a coil of wire carrying a current has merely a *concentrative* and not a *creative* effect as regards the lines of force. The next four chapters are occupied with the subject dynamos, which the authors succeed in rendering very clear and interesting to the student, who is not troubled with the details of any but the best types of modern dynamo machines. Motors, transformers, secondary batteries, and arc lamps, are next touched on. Chapter XVI., which is devoted to incandescent lamps and photometry, is an especially good one. The manufacture of incandescent lamps is described as fully as can be expected, and the authors are at some pains to demonstrate "the utter unreliability of the standard candle." The last chapter deals with conductors, fittings, meters, &c.

The authors, it will thus be seen, cover the ground of electric light and power engineering; and we do not think that with the generic title of "Electrical Engineering" which they have chosen for their work, it would be unduly enlarging its scope if concise chapters on land line and submarine telegraphy and telephony were to be added in the next edition.

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THE INTERNATIONAL TELEGRAPH CONFERENCE.

On Tuesday last the representatives of the Submarine Cable Companies, now present in Paris, entertained M. Jules Roche, the Minister of Commerce, Industry, and the Colonies, and a number of delegates at the Hôtel Continental. The luncheon was given by the following Companies:—The African Direct, the Anglo-American, the Brazilian Submarine, the Cuba Submarine, the Direct Spanish, the Direct United States, the Eastern, the Eastern Extension, the Eastern and South African, the Great Northern, the Black Sea, the Indo-European, the Spanish National, the West African, the West India and Panama, the Western and Brazilian, and the Western Union.

The chair was taken by Sir John Pender, K.C.M.G., and M. Roche occupied a seat on his right. Amongst those present were:—The Marquis and Marchioness of Tweeddale, Mdme. Roche, Sir James Anderson, Sir E. Vincent, Baron d'Itapiba, Commander Nielsen, M. Hake, Commander Ponzio Vaglia, Chevalier d'Obentraut, the President of the Havre Chamber of Commerce, M. Baron, M. Marguerittes, Mr. Palmer, M. Mansi, Sir A. J. Leppoc Cappel, Sir E. Blount, Mr. Lamb, Sir F. Dillon Bell, M. de Selves, Comte de Lesseps, General Besack, Baron Pfeffel, General Agha, Colonel Höncke, Dr. Benesch, Dr. Rothen, Dr. Gollner, Artin Pacha, Tigrane Pacha, Admiral Vallon, Colonel Mallock, Captain Suenson, Don Vazquez, the Rev. H. Hart, Mr. R. K. Gray, Mr. Thomas Fuller, Mr. C. Burt, Mr. W. Andrews, Mr. G. von Chauvin, Mr. Mourlon, Mr. G. Draper, Mr. F. E. Hesse, Mr. F. C. C. Nielsen, Mr. Moll, Mr. C. W. Earle, Le Vicomte Reverend, Mr. Fischer, M. Despecher, M. Blowitz, Mr. Payton, M. Le Sage, Mr. Beaumont, M.P., Mr. Gerhardi, Mr. Ansell, Mr. Wells, M. Serpos, Messrs. Hofstede, Neuman, Tomara, Vigil, Kurino, Seghin, Bordelongeu, Becu, O'Brien, Garambois, Braive, Neubauer, Radcliffe, Mattheeff, André, Hlaweek, Raymond, Marsilly, Broquisse, C. Clarke, Fribourg, Gatliff, Gramaccini, Frouin, Hibberdine, Condie-Stephens, Coromina, Crawford, Uddenberg, Favette, Moret, Bocher, Benton, Menier, Ansault, de Laboulaye, Goldschmidt, Olivarius, Melcom, de Baudel, Willan, Depelley, Scheffler, Tessier, Dimitresco, Ivasakai, Dürr, Nerot, Desmazières, Barker, Neilson, Greer, Tourtay, Dumas, Caso, Frayssinier, Soutzo, Ivanoff, Cordero, Peyerle, Sieblist, Seligman-Lui, Mongenast, Gvozditch, Van Eck, Forestier, Rebuffel, Bugge, Mooney, Smith, Lanng, Tsubono, Berthot, Aylmer, Perk, Bluet, Köller, Antonopölo, Gody, Phakdi, Eschbaecher.

During luncheon Sir JOHN PENDER proposed "The Health of the President of the French Republic, the Queen of England, and the Reigning Sovereigns and Presidents of the World." He then rose and proposed "The Health of his Excellency the French Minister of Commerce, Industry, and the Colonies." In doing so he said: The gentleman whose health I am about to propose presides over the commercial destinies of this great country, and his position is of the highest responsibility, and, let me add, is no sinecure. We are well aware of his ability to direct great affairs, because we have had the opportunity of judging how well he has conducted the Telegraph Conference which is now being held in this grand city. The nations in modern times are all, as we see, most anxious to promote and advance their commerce, knowing that successful commerce makes a prosperous and happy people. France is fortunate in having a Minister who is animated by the highest sense of responsibility attached to the important duties he so ably fulfils. I hope it will not be unbecoming on my part to say a few words in regard to the telegraph companies, representing as I do a large body of submarine and other telegraph companies who are your hosts to-day, and who are at the present moment playing an important part in bringing the nations of the world into closer and more harmonious communication. We may claim to have promoted progress, political, commercial and social. When the history of the last half of this century is written it will be found that telegraphy will occupy an important page. When we take thought of the vast millions of money which are turned over by the nations of Europe in their relations beyond the sea, and when we bear in mind that these operations are initiated, followed up, and completed by the telegraph, we can form some idea of the benefits which our telegraph system has conferred upon the civilised world. Further, when we see the nations vieing with each other in the desire to promote the prosperity of and extend their colonies, and to take their part in the development of Africa, that dark continent which is so much before the public at the present moment, and in the extension of civilisation, we recognise the beneficent fact that telegraphy not only assists in the improvement of the nations themselves, but in the development of trade and industries for the benefit of the teeming millions of the world and in supplying the requirements of humanity. Telegraphy has been the pioneer of this good work. We have just surrounded Africa with our telegraphs, and it is now in almost instantaneous communication with the civilised portions of the world. The systems which I have the honour to represent possess a great international net-work of industrial communication. The mission of telegraphy is to encompass and draw closer the unity and friendship of the nations—in fact, to bring peace and goodwill to the peoples. A few figures, by way of justifying this statement will demonstrate the importance of telegraphy. There are 2,000,000 miles of land lines, valued at 1,550,000,000fr. (£62,000,000). The cables belonging to the Governments at present amount to 13,178 miles, valued at 100,000,000 fr. (£4,000,000). The cable companies have 107,000 miles of cable, costing 900,000,000fr. (£36,000,000), or a total capital of 1,000,000,000fr. (£40,000,000). The total expenditure on land lines and cables has been 2,500,000,000fr. (£100,000,000). The cable ships employed in keeping these cables in repair number thirty-six, with a tonnage of 53,780 tons. I may say that all this has been done within the last fifty years, and the greater portion of the submarine system has been accomplished within the last quarter of a century: it has scarcely yet attained its majority. Permit me to add, for your information, that the time occupied by messages between London and Egypt is twenty minutes, Bombay considerably less than an hour, China two hours, Australia less than three hours—that is for business messages. Between London and New York the time is 2min. 40sec. It is an axiom that countries which acquire colonies and desire to keep their place in the vanguard of progress must have their colonies connected with the mother country by submarine cables. I hope your Excellency will gather from these remarks the great influence which these companies have had and are having in promoting the commerce of the world. I believe our beneficent work is appreciated by each of the nations, and by none more than the great people whose commercial interests are presided over by your Excellency. I give you the toast of "Jules Roche, the Minister of Commerce, Industry, and the Colonies," whose health I now ask you to drink.

M. JULES ROCHE, who was repeatedly cheered, replied as follows:—I thank Sir John Pender for the extremely kind and cordial words which he has spoken in regard to myself. I have not so far forgotten the English that I learned at school as to fail to grasp the leading points of his eloquent speech. He was anxious, so far as I was concerned, to throw into his speech as many fragrant flowers as those which grace this table. But I forgive him the more readily from the fact that I transfer to the Government whom I have the honour to represent all the flattering things that he has said in regard to myself. Gentlemen, I thank you also; I thank all the telegraphic companies, foreign and French, who have invited us to this gathering under the presidency of Sir John Pender; and especially because they afford me the opportunity of greeting—for the last time, to my great regret—the members of the International Telegraph Conference who have just been, for our pleasure and our honour, our guests for a month. In the picture that Sir John Pender has traced in so masterly and picturesque a manner of the great things accomplished by private companies, in showing the endless networks that they have thrown across continents and oceans for the transmission of human thought, in his picture of the prodigious rapidity with which the orders of the human will are carried from one end of the world to the other—when, for instance, he spoke to us of business despatches exchanged in 2min. 40sec. between London and New York—he was implicitly passing the most complete eulogium on private initiative and the great things that it is able to accomplish. And when I heard him juggling, as it were, with the hundreds of millions of francs that have been thrown into those vast undertakings, it seemed to me, from my old acquaintance with figures, that I was again taking part in a general Budget debate. But, gentlemen, the telegraph companies are much more fortunate than States, inasmuch as the money they spend is laid out on undertakings that are, all of them, productive, all tending to the progress of civilisation, and to fraternity among peoples; and, unfortunately, we cannot say as much for the money expended under all the Estimates of great States. But the great strides of science induce us to hope that the day will come—would that it would come with telegraphic speed!—when the Budgets of great nations will resemble those of great private companies. I therefore thank all the companies who have invited us to this banquet, and Sir John Pender, who presides over them, for the high example of social instruction thus given us; and I very cordially drink to their prosperity and their health, because their prosperity and their health imply those of commerce and industry, which, as you have been reminded, have been confided to my efforts and to my zeal.

Captain SUENSON, representing the Great Northern Telegraph Company, in proposing the toast of M. de Selves, paid a graceful compliment to France for the charming hospitality bestowed upon her guests. He also thought the practical side of the Conference's labours equally worthy of special commendation. In the name of all the companies present he thanked the Government most cordially for the kindly reception extended to them, and congratulated it upon the appointment of a gentleman so deserving of its confidence in every respect as M. de Selves.

M. DE SELVES, in responding, said he was sure the delegates of the different Governments present at the Conference just brought to a close regarded the representatives of the cable Companies as collaborators who were as useful as they were agreeable. M. de Selves expressed a hope that his Administration would consistently follow the path of liberal-minded progress of which the labours of the Conference had been a happy reflex. One of the greatest honours of his career would be that of having presided over their deliberations, and he heartily drank to the health of all the representatives of the States and the delegates of the companies invited to the Conference.

Sir JOHN PENDER then said: I have one duty, ladies and gentlemen, to perform, and that is to thank his Excellency and Mme. Roche for their presence here to-day, and to express, on behalf of the companies, their hearty appreciation of the way in which you have responded to their invitation, and to offer to the delegates from the different States of Europe our sincere acknowledgments for the kind consideration shown to us throughout the Conference.

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LIFE AND EFFICIENCY OF ARC-LIGHT CARBONS.*

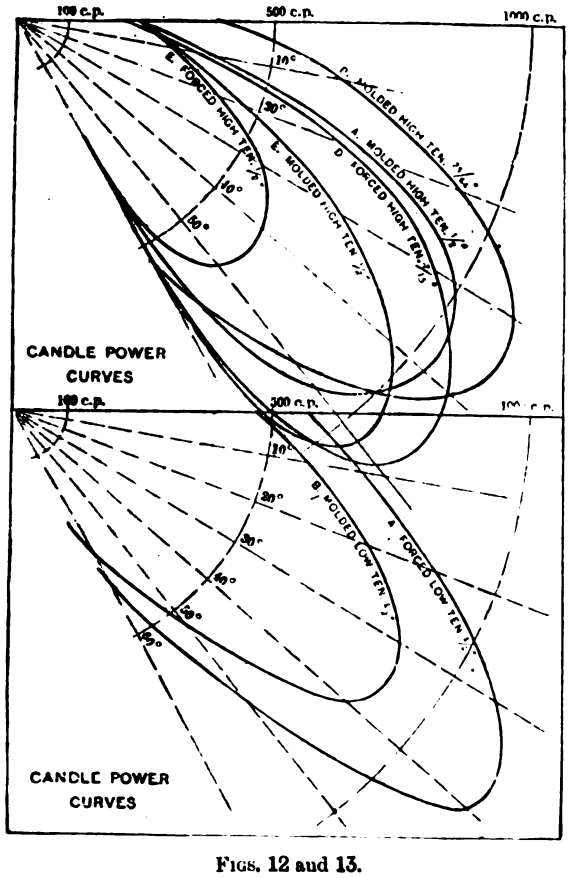
BY LOUIS B. MARKS, M.E.

(Concluded from page 153.)

Candle Power Measurements.

The candle-power measurements consisted chiefly in the determination of the hemispherical candle-power of the different pencils, and from this quantity the watts per spherical candle-power produced. The runs were made under the same conditions as in the efficiency tests. For high-tension carbons, current = 9 amperes and potential difference = 45 volts. For low-tension pencils, current = 21·5 amperes and potential difference = 30 volts. To ascertain the candle-powers, the method of the Franklin Institute Committee was used.† The photometric apparatus was somewhat different in detail from that ordinarily used in measuring the candle-power of incandescent lamps, and deserves a brief description.

The arc-lamp was suspended from an arm which could be rotated about an axis parallel to the photometer-bar and vertically above it. By manipulating a rope connected with the arm, the latter could be raised until it was at right angles with the photometer-bar or lowered until it was horizontal. The arm being horizontal, the lamp was hung from its extremity so that the arc was on a level



FIGS. 12 and 13.

with the centre of the photometer-disc. It will be seen that when the arm was pulled up, the arc described a vertical circle, the axis of which was a line parallel to the photometer-bar and passing through the centre of the disc. The centre of the vertical circle was at the point (800) of a scale graduated into (1,000) divisions, and the radius equal to the length of 200 scale divisions. At the zero of the scale was placed a Weston incandescent lamp and a circular mirror of silvered glass, the axis of which was horizontal, and inclined 45 degrees to the reflecting surface; it was mounted on the bar so that its centre coincided exactly with the 800th division of the scale. Thus the distance between the arc-lamp and the mirror was rendered constant for all elevations of the former, and when the mirror reflected the light of the lamp upon the disc the angles of incidence and reflection were always equal to 45 degrees. The virtual image of the arc under these circumstances was at the 1,000th division of the scale. The Weston lamp was used as a secondary standard and maintained by a storage battery throughout the run at 115 volts; its candle-power was ascertained before and after the tests by comparing it with a standard Methven "Board of Trade" 2 candle-power slit. Photometer readings were made as in the case of the efficiency tests, at 0 degrees, and at 10, 20, 30, 40, 50, and 60 degrees, below the horizontal, the mean of twenty observations being taken for each elevation. These measurements were multiplied by the candle-power of the secondary standard, and corrected for absorption of light by the mirror.

Tables XVII.-XXIII. give the corrected data, which form the basis of the candle-power curves (Figs. 12 and 13). Distance measured along the radii from the origin to each curve give the candle-power for the various angles. The mean spherical candle-power for any case is measured by the radius of a semi-circle whose arc is equal to the area of the candle-power curve. Although great care was taken in ascertaining the candle-powers, the difference in colour between the light emitted by the arc and that given by the standard was so marked that the setting of the photometer-carriage was to a large extent a matter of personal judgment; hence the measurements given cannot be considered as absolute, but rather as relative values.

The conclusions drawn from the efficiency curves hold general, as will be seen by an examination of Table XXIV, for the candle-power curves. From the latter it appears that the efficiency of low-tension carbons, and especially of *moulded* low-tension pencils, is comparatively small. While the efficiencies of moulded high-tension carbons are as high as ·953 and ·888 watt per spherical candle, or 783 and 840 candles per electrical horse-power expended in the lamp, the efficiencies of low-tension pencils of nearly the same diameter as the high are as small as 1·255 and 1·612 watts per candle, or 594 and 502 candles per electrical horse-power. This fact is not brought out in Table XVI., for reference to the latter shows the low-tension pencils to have a rather high efficiency, and in some cases considerably higher than the high-tension carbons. However, when the energy expended in the lamp in the two cases respectively is taken into account, the explanation of the high values for carbons A and B (Table XVI., low tension) is apparent.

Table XVII. *Carbon A. Moulded High Tension.*

Angle.	Candle-power.
0°	221·3
10°	474·1
20°	713·1
30°	979·2
40°	1053·0
50°	928·6
60°	370·7

Table XVIII. *Carbon B. Moulded High Tension.*

Angle.	Candle-power.
0°	382·2
10°	638·4
20°	908·4
30°	1113·0
40°	1131·0
50°	749·3
60°	579 8

Table XIX. *Carbon D. Forced High Tension.*

Angle.	Candle-power.
0°	210·5
10°	407·4
20°	687·4
30°	977·1
40°	1079·0
50°	1140 0
60°	595·7

Table XX. *Carbon E. Moulded High Tension.*

Angle.	Candle-power.
0°	227·3
10°	288·8
20°	429·9
30°	722·2
40°	957 2
50°	1080·0
60°	414·0

Table XXI. *Carbon E. Forced High Tension.*

Angle.	Candle-power.
0°	221·7
10°	238·0
20°	350·1
30°	558·9
40°	626·3
50°	630·7
60°	265 5

Table XXII. *Carbon A. Forced Low Tension.*

Angle.	Candle-power.
0°	593·7
10°	712·1
20°	866·3
30°	1094 0
40°	1183·0
50°	682·2
60°	495·4

Table XXIII. *Carbon B. Moulded Low Tension.*

Angle.	Candle-power.
0°	475·4
10°	593·7
20°	720·9
30°	871·3
40°	866·6
50°	528·4
60°	354·8

Carbon B (moulded high tension, Table XXIV.), it will be noted, has the highest efficiency of the group. This is due largely to the fact that its diameter is smaller than that of any of the others, for "the candle-power varies inversely as the diameter."* Similarly the relatively high candle-power of carbon D is accounted for by the small diameter of the pencil. In Table XXIV. and the candle-power curves we again note the comparatively small efficiency of *forced* high-tension carbons. The efficiency of carbon A (moulded high tension, Table XVI.), as measured by $\frac{\text{luminous radiation}}{\text{total radiation}}$ is larger than that of carbon D; yet the mean spherical candle-power of the latter is greater than that of the former (Table XXIV.). The explanation of this phenomenon, assuming the measurements to be correct, probably lies in the difference in the *quality* of the light emitted.†

* Read before the General Meeting of the American Institute of Electrical Engineers, Boston, May 21, 1890.

† Reports: International Electrical Exhibition of Franklin Inst., 1884. Group B. Sections V. and VIII.

* M. Schreihage: *Centralblatt für Elektrotechnik*, No. 22, 1888.

† The reader is referred in this connection to "A Spectrophotometric Comparison of Artificial Sources of Illumination." Paper by Edward L. Nichols and W. S. Franklin, read before A.A.A.S. at Cleveland August, 1888.

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In some instances it is desirable to ascertain the mean spherical candle-power of a lamp approximately, without taking the time to integrate the curve. The formula given by M. Gérard, namely, "spherical candle-power = ⅓ horizontal candle-power + ⅔ maximum candle-power" * is of sufficient exactitude for practical purposes.

Table XXIV.—*Candle-Power Measurements.*

Carbon.	Diam. Mean inches.	Resistance. Ohms.	C. Amperes.	P. D. Volts.	Horizontal candle-power.	Maximum candle-power.	Hemi-spherical c.-power.	Watts per spherical c-power.	Spher. c.p. per electrical horse-power.
A. Moulded high tension	·508	·208	9	45	221	1053	456	·888	810
D. Forced high tension	·457	·187	9	45	210	1140	486	·833	895
B. Unplated moulded high ten.	·453	·224	9	45	382	1131	525	·771	967
E. Moulded high tension	·533	·202	9	45	227	1080	425	·953	783
E. Forced high tension	·522	·251	9	45	222	626	288	1·407	531
A. Forced low tension	·500	·072	21·5	30	594	1183	514	1·255	594
B. Moulded low tension.....	·498	·071	21·5	30	475	871	400	1·612	502

Data collected from varions sources, including the tests of the Franklin Institute Committee in 1884, show that in some cases the error is less than one per cent. The mean error is, however, larger than that obtained by Gérard himself, and reaches about 9¾ per cent. Hence, as was stated before, the law is valueless except in cases of rough approximation. Reference has been made to the fact that while the curve for luminous radiation is similar to that of candle-power, the curve for total radiation differs widely from the latter. As the efficiency depends upon the ratio $\frac{\text{luminous radiation}}{\text{total radiation}}$ it is plain that Gérard's law will not hold for calculating the mean spherical efficiency from the horizontal and the maximum. But again, for approximations a similar law holds, *i.e.*,

Spherical efficiency = ¼ *horizontal* + ¾ *maximum.*

Although the topic of efficiencies has been discussed in another part of the article, it may not be out of place to add a few words here, bearing upon the law in question. Measurements of horizontal maximum and mean spherical efficiency, made by Mr. H. Nakano and by the writer, are given in Table XXV., and the last law mentioned applied in the calculation of the spherical efficiency. In some cases the error is exceedingly small, while in others it is comparatively large; the mean error of 14 tests is not quite eight per cent.

Table XXV.—*Observed and Calculated Efficiencies.*

Carbon.	Horizontal efficiency.	Maximum efficiency.	Spherical efficiency observed.	Spherical efficiency calculated.
	%	%	%	%
·832in.....	1·82	9·00	6·87	5·60
·563in.....	4·12	14·41	11 00	11·83
·500in.....	4·91	17·33	12·66	14·22
·450in.....	5·48	15·52	13·30	13·01
·370in.....	5·55	17 50	15·54	14·51
·250in.....	8·44	19·80	16·60	16·96
A. Moulded high tension..	5·53	16·21	11·71	13·53
D. Forced high tension ...	4·42	12·57	10 01	10·53
B. Unplated high tension.	8·89	13·52	12·69	12·37
B. Plated high tension.....	9 91	13·69	12·72	12·75
E. Moulded high tension .	2·33	11·05	8·96	8 87
E. Forced high tension ...	2·28	8 95	7·76	7 29
A. Forced low tension.....	5·42	13 51	11·05	12·68
B. Moulded low tension...	5·69	12·73	9·32	10·96

Observations of the Arc and the Carbon-points.

With a given potential difference between the terminals of the lamp, the length of the arc depends upon the current flowing, and increased as the current becomes greater. If the current be kept constant, the length of the arc increases with the potential difference. Data given in Tables 26 and 27 show the length of the arc for both cases.

In order to measure the length of the arc, a lens was so mounted as to throw the magnified image of the former upon a surface carrying a vertical scale. Then after measuring the distance between the magnified points and applying the proper reduction factor, an additive correction was made for the depth of the crater, thus giving the length of arc from the tip of the minus-pencil to the point directly above in the centre of the crater of the plus.

From the figures (Tables XXVI. and XXVII.), it seems that no direct relation exists between the length of the arc and the current and potential difference. In the case of the carbons tested, the length of the arc with constant potential increased very rapidly as the current was changed from 6 to 9 amperes, and then gained slowly from 9 to 13 amperes. The nature of the change was somewhat different in the constant current runs, the length of the arc increasing more nearly as the square of the voltage.

After each of the runs noted in Tables XXVI. and XXVII., the carbon-points were examined, and it was found that the latter assumed particular shapes depending upon the current and potential difference used. Another series of tests were made with carbons C. and E. (moulded high tension), in which the current ranged from 5 to 15 amperes, the potential difference being kept constant at 50 volts.

Table XXVI.—*Length of Arc: Constant Potential.*

Carbon.	Current amperes.	P. D. Volts.	Length of arc. Inches.
E. Moulded high tension.....	6	50	·087
" "	7	"	·114
" "	8	"	·137
" "	9	"	·147
" "	10	"	·150
" "	11	"	·154
" "	12	"	·156
" "	13	"	·167

Table XXVII.—*Length of Arc: Constant Current.*

Carbon.	Current amperes.	P. D. Volts.	Length of arc. Inches.
E. Moulded high tension.....	10	40	·073
" "	10	45	·095
" "	10	50	·141
" "	10	55	·186
" "	10	60	·216

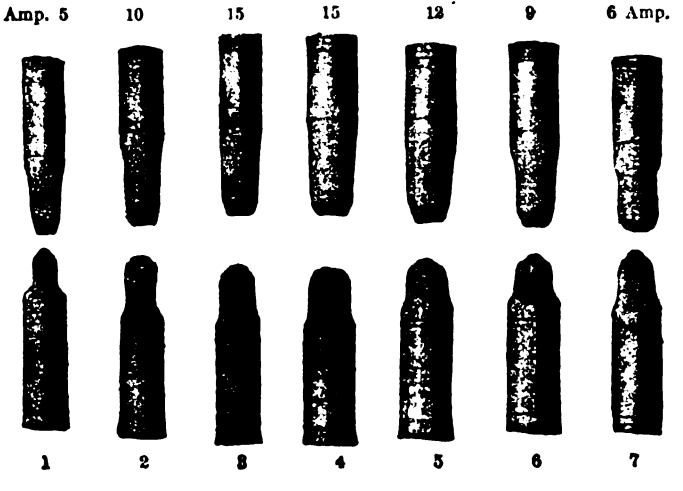

Fig. 14.—Form of the carbon points; constant potential = 50 volts.

Fig. 14 shows the form of the points with different currents. Nos. 1, 2 and 3 are pencils of the brand C., and 4, 5, 6 and 7 of the type E. Examining the first three pencils, we see that with 5 amperes, there is a tendency to form a "mushroom" on the lower or negative carbon; the latter is eaten away considerably just below the tip. With 10 amperes this tendency is not at all marked, and at 15 almost inappreciable. Glancing at the upper or positive carbons, it appears that the smaller the current, the more nearly does the positive pencil burn to a point; that is, the smaller the diameter of the crater. But though the width of the crater is less in the case of low currents than with high, the depth of the former is correspondingly greater. The photographs do not bring out this point, but an inspection of the tip of the lower carbon gives a clue to the facts. Note that with small currents the negative electrode terminates in a pointed, sometimes globular projection. As has been stated before, th s tip becomes less noticeable with increase of current, a fact which is brought out by inspecting Nos. 7, 6, 5 and 4 (Fig. 14). In No. 4, burned at 15 amperes, the end of the lower carbon is blunted; the depth of the crater in the upper was practically zero. In Nos. 5, 6 and 7, burned at 12, 9 and 6 amperes respectively, the depth of the crater increases as the current diminishes. With high currents, the carbon is disintegrated to a greater distance above the point than with low.

Fig. 15 shows the form of the carbon points when the latter are burned with constant current = 10 amperes. The range in potential difference was from 40 to 60 volts. Just as the peculiar burning of the tip distinguishes a pencil fed by a low from one burned at a

*. M. Gérard: Candle-Power of Arc Lamps, *Centralblatt für Electrotechnik*.

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high current, so the form of the carbon-point differs in the case of a pencil burned with low voltage than with high. In Nos. 1, 2, 3, 4, and 5 (Fig. 15), the gradual change in the formation, from a sharp projection at 40 volts to a blunt end at 60 volts, is noticeable. The "mushroom" which invariably forms in carbons burned at a low current and high voltage, is absent when the pencils are burned at high current and low voltage.* In the former instance the thin neck of the "mushroom" often breaks, thus arresting the current and extinguishing the arc. In the latter case the end of the carbon is prone to so burn away as to leave a concave outline. (See No. 1, Fig. 14.) At 40 volts the depth of the crater measured ·051 inch. At 60 volts the crater disappeared; the carbons also "flamed" at this high voltage.

With a given current there is for every brand of carbon a certain voltage, above which, if the pencil be burned, "flaming" will result. A simple trial is sufficient to determine this critical point.† Again, there is a voltage below which, if the carbon be burned, "hissing" takes place. With perfectly centred carbons there is no difficulty in ascertaining the latter point. Careful observation of the arc shows that when the tension is too high for a given carbon the walls of the crater break away, allowing the arc to play on the outside surface of the carbon. This action is always accompanied by a flame, which shoots from the negative carbon. On placing the negative pencil above and the positive below, the flame shoots down. With soft-cored carbons, well centred, one cause of flaming—namely, liability of the arc to play laterally—is obviated; and if the pencils be burned with the proper current and voltage, there seems to be no reason why this disagreeable feature of the arc-lamp should not be entirely overcome. There is not so much liability to "hiss" in a high-tension system as in a low, for from the formation of the carbon-points, when the pencils are burned in commercial low-tension lamps, it appears that the negative carbon terminates in a small mushroom-button. The breaking of this

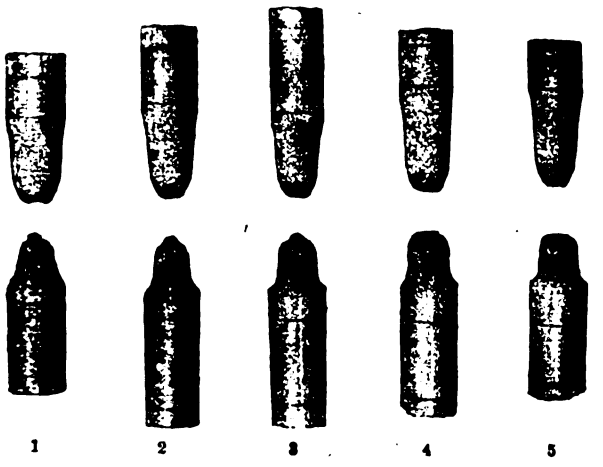

FIG. 15.—Form of the carbon points; constant current = 10 amperes.

pellicle of carbon, and the consequent action of the lamp mechanism to reduce the rise in potential due to the rupture, invariably result in the "hissing" of the arc. Most of the irregularities in the action of arc-lamps probably result more from the unsuitableness of the carbon than from defects in the lamp-mechanism or changes in the strength of the current and potential difference in the line. The remedy lies with the carbon manufacturer. A careful study of the relation between the microscopical structure of the pencil and the action of the latter in a given case would be likely to bear fruitful results. Of course the field for experimentation is large, but the improvements which must necessarily follow conscientious research will undoubtedly be of great scientific as well as commercial value. In the present state of the art of carbon-manufacture, it is the central-station manager who must exercise great discrimination in the selection of arc-light pencils for his plant. Mr. E. F. Peck has recently shown how a "comparative test of the best known carbons in the market" resulted in "a saving of 64·73 electrical horse-power in a station burning a thousand arc-lamps."‡ But there is no reason why the carbon manufacturer, given the condition of a lighting system as regards current, tension, required light and life of pencils, &c.—should not be able to produce a carbon specially adapted to the needs of that system. When the root of existing defects is thus struck at, the solution of the arc-light carbon problem will be at hand.

The experiments published in this paper were made under the direction of Professor Edward L. Nichols, in the laboratory of Cornell University. The writer is indebted to Mr. A. B. Levy, P.G., for valuable assistance in the work.

* When the carbon is impure and contains a large amount of silica, the latter is often deposited in the form of a glass bead on the point of the negative pencil. The "mushroom" alluded to in the text does not refer to this deposition.

† O. G. Pritchard: Electric Arc Light Carbons. *Electrician*, March 21st and April 4th, 1890.

‡ E. E. Peck of Brooklyn, N.Y.: Carbon Tests,—Paper read before National Electric Light Association; Kansas City. (See *Electrician*, March 14, 1890.)

THE ELECTRIC CURRENT AS A TRACTION INCREASER.*

BY ELIAS E. RIES.

Within the past three or four months a number of articles have been published in the electrical journals purporting to show, some theoretically and others by experiment, that the passage of an electric current between a driving wheel and rail could have no effect in increasing the traction or coefficient of friction between the two surfaces in contact, and that if the current had any influence at all upon the friction it could only act to reduce the traction instead of increasing it. As the writer was probably the first to call general attention to the importance of increasing tractive adhesion by the direct action of the electric current, and the first to point out the laws bearing upon this subject, as determined by experiments made by him several years ago for that purpose, it seems fitting that he should reply to these articles.

It appears to have been taken for granted by many persons, probably because the phenomena of increased traction were first observed in the operation of electric railway motors, that the mere use of the track rails as the return conductor in an electric railway system is all that is necessary in order to ensure increased adhesion between the motor wheels and the rails. This is by no means the case, as the result is entirely dependent upon the nature of the current employed and the circumstances under which it is permitted to act. As a matter of fact, the conditions existing on single-trolley railways, as at present operated, are not such as to be favourable to the production of increased traction; and although a certain amount of increase in adhesion occasionally manifests itself, it is not such as to be relied upon with any regularity or certainty, and is due, as will hereafter appear, to causes entirely different from those that produce increased traction in cases where a local or independent traction circuit moving with the vehicle is employed, such as embodied in the method of electrically increasing traction devised by the writer.

In my original Paper upon this subject, read before the American Association for the Advancement of Science in August, 1887, the underlying principles and conditions governing the production of increased friction by the action of the electric current were set forth for the first time in the following paragraph:—"Before entering into a description of the means by which this result is produced, and how it is proposed to apply this method practically to railway and other purposes, it may be well to give a general outline of what has so far been determined. These experiments have shown that the coefficient of friction between two conducting surfaces is very much increased by the passage there through of an electric current of *low electromotive force and large volume*, and this is especially noticeable between two *rolling* surfaces in peripheral contact with each other, or between a rolling and a stationary surface, as in the case of a driving wheel running upon a railway rail. This effect increases with the *number of amperes of current* flowing through the circuit of which the two surfaces form part, and does not materially depend upon the electromotive force, so long as the latter is sufficient to overcome the electrical resistance of the circuit. This increase in frictional adhesion is principally noticeable in *iron and steel*, although present in other metallic bodies, and is due to a molecular change in the conducting substances at their point of contact (which is also the point of greatest electrical resistance in the circuit) *caused by the heat developed at that point*. . . . The most economical and efficient results have been obtained by the employment of a transformed alternating current of *extremely low electromotive force, but of very large volume or quantity*, this latter being *variable at will*, so as to obtain different degrees of frictional resistance.

The correctness of the principles originally set forth in the above paragraph have been repeatedly substantiated by subsequent experiments, and it will be seen therefrom that, in order to produce increased traction by the direct action of the electric current, the following conditions must be observed:—1. The current must be of such volume as to produce an appreciable amount of heat at the point or points in contact. 2. The electromotive force must be as low as possible. Experiments made by the writer have shown that a high electromotive force has a tendency to

* From the *Electrical World* (New York).

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diminish friction, especially if the pressure between the surfaces in contact is a moderate one. 3. The metals in contact should be of iron or steel, as these have the requisite electrical resistance at their contact surfaces, and are of such molecular structure as to permit of a close and intimate union between them under the influence of the current. 4. One or both of the metals should preferably roll upon the surface of the other. This is desirable in the first place, in order to economise current by concentrating the heating effect upon as narrow a line of contact as possible. Furthermore, a rolling motion, where the line of contact moves progressively and uniformly along both surfaces, as in the case of a wheel and rail, where the contact is continually established at new points, requires less current to produce a given tractive effect than in case of sliding friction, where the surfaces move at different rates of speed, and are never in fixed relation to each other for an appreciable length of time.

Let us now see whether or not these conditions have been fulfilled by those who have endeavoured to show that the electric current is incapable of increasing tractive adhesion. We will then look at the matter from a more practical standpoint, and show what the electric current has done, and is capable of doing, in this direction, when properly applied. Prof. Lucian I. Blake, in a Paper recently read before the Kansas Academy of Science, describes and illustrates a number of experiments stated to have been made for the purpose of determining whether an electric current would, as stated, increase the friction between a wheel and rail in electric railways. Four different experiments are described, not one of which even *approaches* the conditions met with in railway practice. In two of these experiments such metals as platinum immersed in flowing mercury and a brass bar sliding upon brass rails were employed! The flat surfaces in frictional contact "varied from one and a-half to three square inches," an amount several times greater than the combined effective area of contact of four ordinary railway car wheels, while the current sent through these surfaces was several times less than that ordinarily used in railway practice, being but one ampere and ten amperes respectively! The two remaining experiments illustrated a case of rolling or skidding friction in which the current used was presumably the same as in the first experiment, "varying from 0 to one ampere." In short, these experiments seem to have been devised for the express purpose of showing "how *not* to do it," since Prof. Blake himself admits in concluding that "the currents employed were not sufficient to produce heating at the surfaces of contact," and adds that "such heating would doubtless produce an increase of the coefficient of friction." Mr. O. T. Crosby has also described some dynamometer tests tending to show that no increase in traction occurs. These tests were made by him with an ordinary single trolley motor car, and consisted in first returning the motor-operating current through the wheels and rails in the usual manner, and then repeating the experiments with the wheels out of circuit. The current employed was varied from 0 to 42 amperes during the experiments, and the electromotive force, though not stated, was probably 500 volts. Unfortunately, the capacity of the dynamometer at Mr. Crosby's disposal was less than that needed to register the ordinary tractive effort of the car on a level track, and he found it necessary to jack up one end of the car so as to *skid* only one pair of wheels and to relieve these of a part of their weight. It will be apparent from what has been said that the conditions under which these tests were made were not only unfavourable to the production of increased traction, but were of such a nature as to bring about the very opposite result.

There seems to be an impression among many persons that the increased traction, if present, must be due in some way to magnetic action. This view of the matter has been taken by Mr. Nelson W. Perry, of Cincinnati, who endeavours to show that no appreciable increase in traction can result from the direct passage of an electric current from wheel to rail, or *vice versâ*, because there would not be sufficient "*attractive*" force produced. It is further stated that the passage of current in this manner could only result in a repellant action between the metals in contact, the author citing, among other things, the action of the electro-motograph in support of his views, and in general denying that increased traction could result by reason of *any* change, molecular or otherwise, caused in the surface of the metals by the action of an electric current, notwithstanding the fact that elsewhere in his communication he admits having witnessed an experimental demonstration in which the current *did* have the effect which he endeavours to prove it *could not* have. It is needless to state that there is not the slightest basis for any of the theoretical conclusions referred to, which probably arise from a misconception of the real actions to which the increased adhesion is due.

We will now consider the part the current plays in the production of increased traction. It has already been said that this phenomenon is directly due to the *heating effect* of the current upon the metals at their point of contact. A certain slight magnetic effect is necessarily also present, but this is so small in the case under consideration that it does not enter to any appreciable extent into the result, and may therefore be neglected. This heating produces a molecular change in the surfaces of the metals, which causes a variation in the coefficient of friction between them; but the nature of this variation and the manner in which the increased adhesion is produced depends upon the nature of the metals and the degree of heat developed at their points of contact. As an illustration of this it may be stated that a moderate current of sufficient strength to cause increased adhesion between iron or steel surfaces will have a lubricating effect upon brass contacts and causes a diminution of the normal friction between them, although with a sufficiently large current the friction may be increased. Experiments have shown that in the case of iron and steel a comparatively slight amount of heat will serve to increase the friction to an appreciable extent, this being due to a slight expansion and elevation of the metal at one or both sides of the normal line of contact. This action is practically spontaneous, the heating effect taking place on the *surfaces* of the metals long before the body of the latter have had time to become sensibly warm. That the particular effect here referred to is due principally, if not entirely, to the heat, and not to the current directly, is proven by experiments made by the writer with a small electric railway model, in which the increased friction continued an appreciable length of time *after* the traction current had been cut off, the wheels of the motor car having been previously heated by the current so as to retain for a time a portion of the heat imparted to them. The friction between driving wheels and rails is considerably increased beyond this point, however, by increasing the current strength so as to produce a still greater local heating of the metals at the point of contact; and this is the method preferred by the writer, and most economically carried out by the use of a closed traction-increasing circuit of low resistance, moving with the vehicle and including the driving wheels and that portion only of the track rails that lie between them. When the current strength is sufficiently augmented the increased traction becomes due to an *incipient welding* of the metals along the line of contact. This action leaves no permanent trace upon the wheels or rails, nor is there any appreciable increase in rolling resistance noticeable. The writer has even increased the current strength so as to produce an actual weld between the wheels and rails, without material injury to either of the rolling surfaces; in some experiments, on overcoming inertia, the metals separating again on the line of the weld, the film of oxide between them. By the employment of a converted alternating current of high periodicity with respect to its volume the heating effect may be confined to the surface of the rails without penetrating into the interior. As a rule, the amount of current needed to produce a given increase in traction is found to be proportionate to the area of the surfaces in contact, and, to a certain extent, to the speed of the driving wheels. The conditions under which increased traction is called for in practice are favourable to the use of a comparatively small amount of electrical energy for this purpose, since it is only in starting heavy loads and in ascending grades, when the rate of speed is much below the normal, that increased adhesion is usually required.

The writer has recently had occasion to construct a small electric motor car and track with which a number of important facts bearing upon this subject have been satisfactorily illustrated. This model is still in existence, and may be seen in successful operation at the writer's office, room 27, Chamber of Commerce Building, Baltimore, at any time. The apparatus in question consists of a small electric railway car having two driving axles insulated from each other and operated by a small electric motor supplied with current through flexible conductors in circuit with a single cell of secondary battery. The driving axles are arranged so that one of several sets of iron or steel driving wheels of different diameters can be placed thereon. The traction increasing current is derived from an independent source, and is varied according to the requirements of the experiment in hand. This current, by means of a second pair of flexible conductors connecting with binding posts on the car, is sent from the forward to the rear driving axles through the intervening driving wheels and track rails, although the arrangement is such that it can be sent directly from one rail to the other across the wheels and axles, thus enabling the terminals of the traction circuit conductors to be attached to the rails at one end of the track instead of being carried by the motor. The weight upon the driving wheels without extra load is about three pounds.

With this apparatus, employing a continuous traction-increasing current derived from one cell of secondary battery, the tractive effect of the motor car was increased considerably over 150 per cent., the car climbing grades of thirty feet to the hundred with perfect ease against the pressure of a spring tending to pull it backwards; whereas, with the same propelling current flowing through the motor, but with the traction circuit open, the car remained spinning at the bottom of a 10 per cent. grade, not having sufficient tractive adhesion to lift its own weight. Upon again closing the traction circuit the car instantly regained its grip upon the rails and shot up the incline until its further upward progress was stopped by the distended spring and cord that secured the car to a post at

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the lower end of the track, and prevented it from running over the top of the incline. No sparking, flashing, or other visible indication that current was passing between the wheels and rails could be observed in this experiment. There is no mistaking the action of the motor, or the important part the current plays in increasing tractive adhesion. If, while the car is ascending a steep grade, the traction-increasing circuit be opened and then again closed, the car will commence to slip backward, and continue doing so with accelerated speed until the moment the circuit is completed, whereupon its descent will be almost instantly checked, and it will promptly proceed to mount the grade again as if nothing had happened. Among other things, it was shown by this apparatus, as originally predicted, that the traction is not diminished, but (compared with mechanical traction under like conditions) enormously increased when the rails are wet or slippery. The presence of water on the rails seemed to make no difference in traction while the current was passing. With the rails and wheel tires thoroughly *oiled* the car remained stationary with the motor running at the bottom of a 6 per cent. grade. One end of the track was then elevated to form a 25 per cent. grade, and on closing the traction circuit the little car actually climbed up the slippery track as far as the spring would permit without a single idle revolution of the driving wheels! On increasing the traction current by connecting a second cell in series with the first, so as to produce a perceptible and progressive incipient welding between one or more of the wheels and rails, the tractive pull of the car on a level track, as measured by a standard spring balance dynamometer, was rapidly increased from six ounces, the normal pull without traction current, to 31 ounces with the current, *an increase of over 500 per cent.!* Were it not for the fact that at this point the load and the tractive adhesion exceeded the maximum power developed by the little motor, the increased traction actually registered would have been much greater. With the same current passing between the wheels and rails the car performed the remarkable feat of ascending without any slip a *50 per cent. grade, part of which was coated with oil!* This experiment has since been witnessed by a number of prominent electricians and engineers, who expressed themselves as astonished beyond measure at the wonderful increase in friction obtained, and the comparatively small amount of electrical energy required to produce it.*

In order to determine some of the conditions bearing upon the application of this system of increasing traction to ordinary railway train service, a series of preliminary experiments upon a large scale were made by the writer nearly a year ago with a locomotive on the Philadelphia and Reading Railroad. These tests were made with a locomotive selected by the railroad company, a "consolidated engine weighing 111,000 pounds (one of the heaviest and most powerful in the service of the road), of which 98,000 pounds, or nearly 50 tons, were distributed over *eight* coupled driving wheels, measuring about 54in. in diameter. The traction current was generated by a special low-tension, direct-connected steam-driving dynamo mounted upon the locomotive, one terminal being connected by a heavy stranded copper cable with the forward and rear pairs of drivers respectively, which were insulated from the frame of the locomotive by special insulated brasses at the boxes and journals, the opposite terminal of the dynamo being connected with the two intermediate pairs of drivers. This arrangement was adopted to avoid interruptions in the circuit at the rail joints, which on this road, as is usually the case elsewhere, were not directly opposite on both rails, but overlapped. The average resistance of the traction circuit with the locomotive at rest measured less than one-hundredth of an ohm, practically all of which was located at the respective points of contact between the wheels and rails. The current could be varied during the different tests by varying the field strength or speed of the dynamo, or both, from about 500 amperes to the maximum output of the machine.

The first experiment was made on a substantially level track, and consisted in coupling the locomotive to a train of 12 loaded coal cars and setting the brakes on these so that the engine could not possibly start the train without continuous slipping, several unsuccessful attempts to do so being made. The dynamo was then started up and the trial repeated with *entire success*, the train being brought under full headway from a position of rest without a single slip of the wheels. This was repeated a number of times, the engineer being instructed to do his utmost to make the wheels slip while the current was flowing, as by suddenly throwing open the throttle to its widest extent with the eccentric lever in its foremost notch, &c., without effect. It was estimated that the load moved by the engine during this test was equivalent to a train of 110 cars!

A number of subsequent tests were made on the Frackville branch of the Reading Railroad, upon a steep mountain grade seven miles in length, averaging 185ft. to the mile, and with numerous sharp and difficult curves. Regular service runs were made over this grade both with and without the current, under conditions as nearly alike as the traffic over the road would permit, with entirely satisfactory results. The official records of the tests show that in nearly every instance the use of the current produced a decided increase in the tractive capacity of the locomotive, and prevented the enormous wear and tear, loss of time and consumption of coal occasioned by the excessive slipping that took place when natural adhesion alone was relied upon. On one occasion the time required to ascend the grade with a load slightly in excess of that usually carried was, without current, 55 minutes, as against 29 minutes with the current flowing, under exactly similar conditions. The amount of coal consumed on the last-named trip was *less than one-half* of that used on the trip without current, by reason of the absence of the rapid exhaust and loss of power consequent upon the slipping of the drivers.

These tests, though made under some disadvantages, were so satisfactory that they are now being continued under conditions and auspices more favourable for carrying out this work. It is estimated that the tractive adhesion of steam locomotives can by this method be increased 25 per cent., and even more in special cases, or where the construction of the locomotive is such as to permit it to utilise a greater increase. This not only means that four locomotives will be enabled to do the work that now requires five, but that longer and heavier trains can be moved, better time made, steeper grades operated, quicker stops effected, inertia more promptly overcome and more fuel saved than by the present methods, and what is perhaps of the greatest importance, without any material increase in the weight upon the drivers or roadbed. These and other advantages are by no means limited to steam locomotion, but apply to electric railway operation with equal or even greater force.

The question will now be probably asked: "Are the conditions existing on electric railways employing the rails as a return conductor for the propelling current such as render this current a factor in increasing the traction, and, if so, to what extent?" Before answering this question let us briefly review these conditions. In the early days of electric railways the potential difference under which the motors were operated was very small, in some cases as low as 120 volts, and the currents correspondingly large. The track rails were usually of some obsolete light-weight T pattern that had done more or less service on some suburban horse railway line, and the bearing surface of which was curved to such an extent that the driving-wheel contact amounted barely to a point. Under these circumstances a useful amount of increased traction was obtainable, especially in starting the motor on a grade, when the flow of current was unusually heavy. On "single trolley" railways, as at present operated, under a potential difference of 500 volts, the currents employed are not sufficiently large to produce increased traction by the *direct heating* of the metals in contact, except when, as sometimes happens, the tread of the wheel runs upon an exceedingly narrow portion of the rail surface, and even this effect is largely if not entirely counteracted by the high E.M.F. of the current. However, a certain amount of increased traction may be, and often is, *indirectly* produced by the current on single trolley railways. This occurs when the contact between the wheels and rails is temporarily interrupted at more or less frequent intervals by particles of sand or other foreign matter on the rails, thereby giving rise to small electric arcs and producing the "flashing" noticed under these conditions. The heat generated by these arcs is, in many cases, sufficient to soften the metal and to cause an actual fusing or welding action between the surfaces of the wheels and rails when they again meet beyond the grain of sand or other obstruction, the latter being sometimes vitrified or decomposed by the arc, or embedded in the heated metal. As the car moves forward, the arc, which is originally sprung behind the obstruction, advances along the wheel and rail to a point in front of it, and the points of the metal thus heated, approaching each other, unite under pressure and almost instantly cool, extinguishing the arc in so doing and producing a more or less perfect weld at the points of contact to which the increased traction is due. The welds thus formed are again broken, during the separation of the wheel and rail surfaces, on their line of least resistance, which is generally that corresponding to the original surfaces, because of the film of oxide and other impurities usually found between the fused metals, and which in most instances prevents a homogeneous weld.

From this it will be seen that notwithstanding the small volume of the current on single trolley railways an appreciable amount of increased traction may manifest itself by reason of the comparatively high electromotive force, producing a change in the action of the current. The use, for example, of a moderate amount of sand in

* It appears that the presence of water or oil upon the rails, as shown by these experiments, has a tendency to confine the passing current to a much narrower and smaller area of contact between the wheels and rails, thereby enabling a given current to produce a much greater heating effect at the very point where it is wanted. In other words, the weight upon the drivers is sufficient to "squeeze out" whatever oil may lie directly under the mathematical line of contact; but the film of oil or water at either side of this line offers sufficient resistance to the low-tension current to confine the passage of the traction current to the exceedingly narrow portion of the wheel surface in actual metallic contact with the rail. Thus, what has always been a decided disadvantage to mechanical traction is, or may be, utilised in a most important manner in increasing traction electrically.

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conjunction with the current on grades of more than usual steepness will serve to increase the adhesion both mechanically and electrically to a certain extent; but this plan is not nearly as efficient, economical or reliable, leaving out for the present the question of its advisability, as the employment of a current of lower voltage and larger volume for the direct and uniform heating of the contact surfaces.

It may be stated in conclusion that, while it is possible to obtain a certain appreciable percentage of increased traction on electric railways in which the propelling current is returned through the wheels and track rails, and while in some few cases a slight increase is necessarily present as a function of the propelling current, yet the conditions under which such roads are usually operated are not favourable to the production of such increased traction. Numerous experiments made by the writer have shown that the most satisfactory and economical method of employing the electric current as a traction increaser, whether on steam or electric railways, is to establish an independent low-resistance circuit, including the driving wheels and so much of the track rails as lie between them, and to charge this circuit with a low-tension traction current capable of producing the desired heating effect. As this circuit is entirely independent of, even though it may be derived from, the motive power of the vehicle, the amount of increased traction can be regulated without regard to the speed of the motor, and can also be used on down grades to assist the brakes in stopping the car. The increase in the adhesion on single trolley roads under the most favourable conditions is limited by the low heating effect of the propelling current, whereas in the case of the independent traction circuit there is practically *no* limit to the amount of increased adhesion obtainable, since this adhesion may be increased to such an extent as to actually weld or "freeze" the driving wheels to the rails.

THE TREATMENT, REGULATION, AND CONTROL OF ELECTRIC SUPPLY BY THE LEGISLATURE AND THE BOARD OF TRADE.

The following is the authorised abstract of the discussion on Major Cardew's Paper :—

Mr. CROMPTON expressed his opinion that the electric lighting industries had suffered considerably from over-legislation, and he disagreed *in toto* with Major Cardew's statement that the Act of 1882 did not do the amount of harm generally attributed to it. He admitted that over speculation in electric light patents had a depressing effect ; but he himself could vouch for the fact that the Act of 1882 prevented a large central station in which he was interested from being carried out. Had this been proceeded with, experience for which we had now to go to America would have been gained first hand. Unnecessary legislation had also caused immature and incomplete schemes to be brought forward, and seriously interfered with the natural development of the industry. The question of sites for stations had been placed in an unsatisfactory condition ; for under present circumstances it was necessary to keep their positions secret, and this necessity caused hurried designs and workmanship, as well as increased cost. He firmly believed that the old method of obtaining private Bills, as for gas works, would have been far more satisfactory to all than the present system of Provisional Orders ; and he felt quite sure that the gas works clauses could have been easily modified to make them applicable to electric lighting stations. Whilst fully admitting that the Board of Trade had done all in its power to make the Acts workable, and that the thanks of all interested were due to the officials for the great efforts they had made, he could not help thinking that the tendency of modern legislation was to interfere too much, and to show people how to do their own work. The case quoted by Major Cardew as to consumers being entitled to the choice of two pressures, one about half the other, was, in his opinion, one of undue interference ; for it was quite as much a pure commercial question as whether a grocer should make up his tea in pound or half-pound packages. Another case of injustice occurs where the supplier is required to provide larger terminals when a greater supply is needed by a consumer than he originally estimated.

Mr. G. OFFER endorsed Mr. Crompton's remarks about the Board of Trade officials being always anxious and ready to deal practically with the questions which arose. He also thought that we suffered from over-legislation. One serious defect of the present system was the inordinate length of time required to obtain a Provisional Order ; for the Preliminary Order must be applied for in July, whilst the confirmation of the Order cannot be granted until August in the following year. Should an unexpected dissolution of Parliament occur in the interval, the consequences would be very serious to the applicants. He submitted that a great improvement might be effected by materially shortening the time between the application for, and confirmation of, Provisional Orders ; or, better still, by avoiding the necessity of obtaining confirmation bills. As this confirmation is not required for licences, he thought Orders might be treated similarly. As to the position of Local Authorities being more favourable than that of private companies under the Acts, he thought this a distinct advantage, for it would facilitate procuration of capital for carrying out lighting schemes, whilst private companies would obtain the work without incurring all the risk. The appointment of electrical inspectors and consulting engineers were points on which he believed Local Authorities were somewhat confused ; and to show the state of some minds on the subject, he cited a case in which a Local Authority wished to appoint an inspector, but stipulated that his salary was to be paid by the undertakers.

Mr. J. SHOOLBRED thanked Major Cardew for the concise account of Provisional Orders which he had given to the Institution. There were one or two points to which he desired to direct attention in connection with such Orders, viz., the necessity for bye-laws and the question of overhead wires. Bye-laws, he said, were becoming more and more important for the protection of undertakers rather than for customers ; this, he was glad to see, had been partly recognised by the Board of Trade in granting access to consumers' premises in some cases, but facilities for examination of fittings, &c., were still required, for vexatious customers can and do throw serious difficulties in the way of undertakers. As regards overhead wires, he pointed out that considerable complication had been introduced by the Board of Trade legalising them to some extent, for it would lead to unfair competition. Many overhead wires had been erected without statutory powers, and if these were permitted to remain, the companies or persons in possession, although they did an illegal act in erecting them, would be allowed a great advantage over another law-abiding company in the same district, which was compelled to put its wires underground. Referring to meters, he asked if any had been certified, and whether steps had been taken towards the formation of branch offices at which meter tests could be carried out. In the event of such offices being established, he wished to know if they would be representative of the central office. Speaking of the clauses in the new model Provisional Order relating to the pressure being declared at the customers' terminals, he pointed out that in some cases a consumer may declare a pressure which it would be practically impossible for the undertakers to supply.

The discussion was adjourned to the 22nd inst.

THURSDAY, May 22nd.

Mr. A. A. CURTIS HAYWARD remarked that Major Cardew's paper touched lightly on the appointment of electric inspectors. He considered the vesting of such appointments for the Metropolitan district in the London County Council a regrettable incident, and was glad to note that in future orders the right of appointment would be vested in the Board of Trade. The appointments were, he said, at present very important, for the public had been somewhat alarmed by the sensational accounts of accidents in America. The knowledge that properly qualified inspectors were to be appointed would tend to restore confidence and give great satisfaction to the community. His opinion as to the future importance of electric inspectors did not coincide with that of Major Cardew, for he believed theirs would be a case of degeneration rather than one of development. He could not agree with Mr. Crompton about over-legislation, and thought the latter gentleman overstated the case when he said that the gasworks clauses might have been easily modified to cover electric supply. A real need for a special Act existed ; for there were many subjects in electric supply, such as overhead wires, &c., which were quite foreign to gas distribution.

Mr. EMILE GARCKE said that he was not prepared to discuss the details of the regulations in the face of Major Cardew's statement that criticism from even a high electrical authority might be erroneous. He would rather confine himself to the historical facts. The parliamentary history of electric lighting was unique, and the rapid changes that had taken place in the industry were phenomenal. The first Select Committee (he said) was appointed in 1879, when the commercial possibility of incandescent lighting was unknown. Its fair report encouraged contracting firms to promote Bills in Parliament. In the spring of 1882 another Select Committee was appointed, and in the same year the memorable Act of 1882 passed. Although its results were lamentable in one respect, he thought it not an unmitigated evil. After detailing the various attempts to remedy the defects of that legislation resulting in the Act of 1888, he pointed out that no time had been lost, and that progress had been comparatively rapid. He laid great stress on the exceptional character of the legislation even of the amended Act, saying that no other industry had ever been placed under such adverse conditions, excepting, perhaps, by the Tramways Acts, but even this was much more favourable to the contractors than the Electric Lighting Act of 1888. The exceptional character arose from the fact that Parliament refused to put electric lighting Corporations on anything like the same footing as gas companies, and thus the former had to compete on very unfavourable terms. It was in the power of the gas companies by foregoing their dividends for a year or two to completely crush electric companies ; for in addition to their power to pay accumulative dividends they had the advantage of practically perpetual tenure, whilst the electric companies were limited to 42 years. As regards local authorities, he complained that according to present regulations it was in their power to stifle electric lighting, and as many of them were largely interested in gas, he argued that it was not right that the electric companies should be placed in such a difficult position. To show how vexatious local authorities may be, he quoted a case of a central station established in the early days of electric lighting. The work was carried out satisfactorily by overhead wires until such time as regulations were issued by the Board of Trade stating that all wires must be put underground. In the face of the 21 years' purchase clause it was financially impossible to comply with the regulations. When the amended Act was passed in 1888, the Company applied for a Provisional Order, but were opposed by the Local Authority, which was at that time negotiating for the purchase of gas works. He was not aware that any other kind of vested interests had been similarly treated.

Mr. K. L. MURRAY expressed the great pleasure he experienced in hearing the discussion on such an important subject, and at being in the presence of so many eminent persons on whose sayings and doings they in Australia were so largely dependent. In Victoria, he said, they had no

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Acts of Parliament or regulations to control electric supply, and until recently they had no rules. Last year, however, the Victorian Institute of Engineers had drawn up a set of rules based largely on those issued by this Institution and by the insurance companies. He did not agree with those who said that electric supply needed no regulation; for defective workmanship should be carefully guarded against, and for this object rules or regulations were necessary. An Act of Parliament, he said, was now expected in Victoria, and the present discussion would aid in framing the Bill. A knowledge of what to avoid as well as what to do might, he hoped, lead to a model Act, from which, perhaps, the mother country might copy with advantage.

Captain ROWAN said that in Australasia, where he had been engaged in introducing electric lighting, difficulties arose from want of legislation. No public body had power to give authority to lay mains or to erect overhead wires, &c., and in consequence matters had come to a deadlock. Mr. Murray, he said, had told them that legislation had been delayed until it was known what was to be done here. He hoped that the present discussion would materially assist those on the opposite side of the globe to hit the happy mean whereby public safety might be assured without the industry being hampered.

Mr. H. HUMAN disagreed with what Mr. Crompton said about the injustice of compulsory supply at either of two pressures, and pointed out that a grocer who made up his tea or sugar in pound or half-pound packages had not a monopoly granted to him for 42 years. In his opinion there was no particular hardship to the undertakers in the regulation, whilst it was a distinct boon to customers. He thought Mr. Crompton, in his remarks about the gas and water companies, had overlooked the fact that they had been sources of complaints for years. His comparison of electricity with gas and water was not legitimate; for in the former case, where such a subtle agent as electricity was dealt with, consumers were much more at the mercy of undertakers. In America, he said, where the industry had not been hampered by legislation, there had been so many accidents and fires that the public were now appealing for control, and the wish had been expressed that a body analogous to our Board of Trade was in existence there. Speaking of safety devices he wished to see their use made compulsory where the pressure exceeded 1,000 volts. In conclusion, he said that the Acts of Parliament, if harsh, were necessary; and he hoped that those who advised the Board of Trade would hold the scales equally between consumer and undertaker.

Mr. A. SIEMENS said it should be borne in mind that the objects of the legislation were twofold: first, to empower electric supply companies, &c., to lay mains in the public streets, and conduct the business of supply in a manner recognised by law; second, to recover charges for supply made to consumers. Both these aims were intended to confer powers on companies which otherwise they could not possess. Originally, he said, the Board of Trade had power to grant Provisional Orders without the consent of the Local Authority, but in the later development neither licences nor Orders could be granted without such consent being first obtained. In contradistinction to the case quoted by Mr. Garcke, he said that in one town a company had started a station in spite of the fact that the Local Authority had obtained a Provisional Order; subsequently, the Company wanted to claim compensation for loss of vested interests. There was only one point in Major Cardew's Paper which he considered disputable, and that referred to testing stations at pillar boxes. In his opinion they were unnecessary, for a recording instrument in the central station should fulfil all requirements. If, however, the Local Authority wanted a separate station, that could be easily arranged.

Mr. J. S. FAIRFAX hoped that no hard and fast line would be laid down as regarded the kind of instrument to be used at testing stations. In his opinion the paragraph in Major Cardew's Paper referred to some kind of dial arrangement, but he thought one on the deposition principle might be more correct.

Mr. ED. C. DE SEGUNDO did not agree with Mr. Crompton about the Board of Trade having gone too far; in fact, he thought it had not gone far enough as regards protection of the public by making regulations for insulation tests. He knew a case where a 1,000-volt circuit was tested at 100 volts, and he pointed out that to test a steam boiler intended to work at 100lb., with water pressure at 10lb., would be considered ridiculous. The testing of house wires was also very important, for in one case he was assured that there was no defect in the insulation, for in the contractor's tests no indication of a leak was obtained. On applying Evershed's ohmmeter with about 100 volts a dead earth was indicated.

Mr. MORDEY, in referring to the question of safety devices, said it was time the subject was settled. The method of earthing the secondary was, in his opinion, perfectly safe. Great opposition had been made, particularly by the insurance companies, to its adoption; but the reasons for such objections were not forthcoming. As far as he could see there was no danger whatever with the secondary volts at 100, for by earthing the middle of the secondary the greatest difference of potential possible was 50 volts. Besides, the method had also the advantage of weeding out all rotten installations. They had used the method on the Continent, and found it quite successful. The fuses, however, often go, owing to persons inserting penknives, &c., into the switches for the object of obtaining agreeable medical shocks. As regards the Cardew device, he pointed out that its cost was not an unimportant item; moreover, it was automatic and might not go off, and generally the fewer automatic arrangements there were about an installation the safer it was.

Mr. A. P. TROTTER inquired what excess of current was required to let the fuses off, to which Mr. Mordey replied that about 20 per cent. above the normal was the ordinary average. In his opinion such currents could not give rise to fires.

Dr. FLEMING asked what occurred in the case of an earthed secondary, when the primary was also earthed! In Italy, where they had had considerable experience in alternate-current distribution, the tendency was in the opposite direction, for the greatest care was taken to perfectly insulate both primary and secondary circuits. He himself had used an earthed secondary at the Inventions Exhibition, and had found no difficulty, but he wished to ask Mr. Mordey what his experience was.

Mr. MORDEY said that no difficulties had been met with.

Major CARDEW, in reply, pointed out that the Board of Trade could not adjust or redress any wrongs, for such changes in the law must be made by Parliament. With respect to the declaration of pressure at consumers' terminals, he said that was rendered necessary by the introduction of transformers, for it was more difficult in such cases to know the fall of pressure in the distributing mains than in continuous-current distribution. He then read the following draft, which is to be inserted in the new Model Orders:—"Before commencing to give a supply of energy to any consumer the undertakers shall declare to such consumer the constant pressure at which they propose to supply energy at his terminals. The pressure so declared at any pair of consumers' terminals shall not, except by agreement, be greater than 115 volts, or less than 45 volts, if continuous, or the equivalents thereof respectively, if alternating, and shall not at any time be altered or departed from except in consequence of any authorised alteration of the corresponding standard pressure. In distribution on the three-wire system, the central terminal shall, for the purposes of this regulation, be considered to form a pair with either of the outer terminals, and similarly for multiple wire systems; and, in the case of a transformation of energy on the consumer's premises, the undertakers shall give the consumer the choice of a supply at either of two pressures, one of which shall be approximately half the other, and in such case the pressure so chosen by the consumer shall be the declared constant pressure." In drafting this clause, he said, advantage had been taken of the flexibility of the transformer system, in the interest of consumers. Mr. Shoolbred's questions with regard to meters were answered in the Paper itself; for he would there see that they were to be certified by a local inspector, and be of a pattern approved by the Board of Trade. Mr. Murray's remarks about contacts between telephone and electric light wires needed careful consideration, for this was one of the chief sources of trouble and danger where high pressures were used. To Mr. Human he pointed out that the issue of a Provisional Order conferred no monopoly whatever. In reply to Mr. Siemens, he could not say why the change respecting the consent of local authorities had been made by Parliament. Such, however, was the case; and the Board of Trade could not dispense with that consent, except in very special cases. As regards testing stations, he thought the arrangement he had suggested would be more satisfactory to the general public than the use of pilot wires and instruments fitted in central stations. To Mr. Fairfax he explained that the reference to dial instruments in pillar boxes was intended for indicating, and not for recording instruments. Speaking of safety devices, Major Cardew said the plan of earthing the secondary got rid of some defects when the earth connection was substantial, but he thought the fire risks were increased by such a procedure. He had heard of fires being caused through a small leakage current having gradually charred wood, and ultimately set it alight. The apparatus bearing his name was, he said, admittedly automatic, but its action depended only on gravity and electrostatic attraction, and neither of these were likely to alter.

LONDON CHAMBER OF COMMERCE.

Meeting of the Electrical Trades Section Committee.

A meeting of the Committee of the Electrical Trades Section of the London Chamber of Commerce was held on the 16th inst., at the offices, Botolph House, Eastcheap, under the presidency of Mr. R. E. Crompton.

The SECRETARY (Mr. Kenric B. Murray) having read the minutes of the last meeting,

The CHAIRMAN stated that the first subject on the agenda paper was to consider the continuation of the correspondent's appointment, salary, &c.; and the only question was, whether this appointment should be continued for another year, with the arrangement as to salary, &c., remaining. Mr. Trotter's appointment had taken an enormous amount of work off his (the Chairman's) shoulders, and had justified the expenditure that had been incurred.

In answer to a question,

Mr. MURRAY stated that it was arranged that half of the salary to Mr. Trotter should be paid by the Chamber, and half by the Section.

After some discussion, a resolution was passed, on the motion of Mr. S. Sharp, seconded by Mr. G. Binswanger, to the effect that a circular should be sent out asking for a subscription of 10s. 6d. per member of the Section towards the amount of the correspondent's salary for the past and the current year.

Major FLOOD-PAGE thought it would be a good thing for the Section to have a small fund in hand to meet such expenses.

Mr. MUSGRAVE HEAPHY afterwards proposed, and Major FLOOD-PAGE seconded, a resolution to the effect that the Committee recommend the continuation of the appointment of the correspondent for another year, "provided that the Council of the Chamber of Commerce continue to supply their half of the salary, and provided that the balance of the salary be obtained by subscriptions among the members or from the guarantors."

Mr. TROTTER, who had preferred to be in an adjoining room pending the discussion of the question of his reappointment, was then invited to join the meeting; and on being informed of the resolution that had been passed, expressed his readiness to again serve the Committee as before, provided that the appointment might be dropped, or that he might retire, on due reasonable notice, if his own work should so increase as to render such a course necessary.

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The Committee then proceeded to discuss the next matter on the agenda paper—"The action of the Board of Trade in regard to overhead wires."

The CHAIRMAN observed that as the matter concerned him personally and others a great deal, Mr. Wharton would, perhaps, state what was being done.

Mr. C. J. WHARTON said he thought it would be best for the Chairman to state what had occurred, and then suggestions might afterwards be made by those present.

The CHAIRMAN: Last year the Board of Trade issued a set of rules to regulate the use of overhead wires, and these rules were submitted to a Committee of the Institution of Electrical Engineers. The Chamber of Commerce attempted to have a voice in the matter, but they were rather late in the day, and were not listened to. He was one of the Committee of the Institution, and, therefore, he could not, without a breach of confidence, tell the meeting what had gone on in that committee further than this, which he thought was no breach of confidence—that the particular rule he was going to speak of was not much discussed, and was, in fact, thought very little of. In fact, they had not specimens before them of the cables which the rule was meant to refer to, and they had not presumed that the Board of Trade rule would make an electrical cable into a "pudding," such as the one now in front of him; and at the time, therefore, no one raised any objection to the rule. They fully imagined that Major Cardew had seen cables himself, and knew what they were before he made the rule. That, however, appeared not to have been the case. The rules in question had been issued for some months. There were a large number of installations using overhead wires, and these were now required to be brought into accord with the regulation. Rule No. 9 was as follows: "Every high-pressure aerial conductor must be continuously insulated with a durable and efficient material, to be approved by the Board of Trade, to a thickness of not less than one-tenth part of an inch, and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation must not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000. This insulation must be further efficiently protected on the outside against injury or removal by abrasion. If this protection be wholly or partly metallic it must be efficiently connected to earth, so, however, as not to cause undue disturbance to other electric lines or works by electrostatic induction or otherwise." Now this rule produced an extraordinary monstrosity for a small wire, and a cable was produced which was totally unsuited to the purpose intended. He had mentioned his view of the matter to Major Cardew, who replied that the rules of the Board of Trade were not like the laws of the Medes and Persians, and that they might be altered; but that the best thing that could be done would be for his Company to get samples of cable, and that they should then be tested, but in a proper way—tested on the living *experimenta*, as he had himself said in correspondence with the Board of Trade. His Company had put up overhead wires at Chelmsford, and the Board of Trade informed them that they were not in accord—and they were not—with the Board's rules, and that they must put up another description, which the speaker exhibited to the meeting. They replied that they could not do so. Then Major Cardew suggested that they should have three cables made—one exactly in accord with the regulations, one exactly what they thought sufficient, and one made midway between the two. These cables were made and experiments were carried out with them in the presence of Major Cardew. The result of the experiment was to show that as far as insulating qualities were concerned, the thin cable was as good as the other. After standing all the tests satisfactorily, and all of them believing that Major Cardew had been thoroughly convinced, they received a letter from that gentleman to say that the Board of Trade saw no reason to amend their rules. They were, therefore, met with a positive blank refusal to consider a matter which had really never been considered. The consequence had been that four or five gentlemen more immediately concerned had met together and had proposed to memorialise the Board of Trade, pointing out the extreme injustice of this decision, and how it was likely to injure the interests of the trade as a whole, and further suggesting that the Board of Trade might re-examine the circumstances and inquire into the matter. The question was of such universal interest to the trade that they had thought it right to bring it before them at that meeting, so that others might join them in their action if they wished to do so. It was a subject that was of supreme importance, and was the first matter that had really touched their pockets to a very serious extent. He believed that both to the Brush Company, Mr. Wharton's Company, and his (the speaker's) Company, it would make a difference of some thousands of pounds in work already done, and it was practically prohibitory of work in the future. It affected villages, small country towns, and places where there was a quantity of electric lighting extending over large areas.

Mr. TROTTER inquired how many electrical engineers or contractors were on the Committee that were technically consulted about the rules in question?

The CHAIRMAN: Two; Mr. Siemens and himself; and, frankly, they did not see how the rule quoted would affect them.

Mr. EMILE GARCKE suggested the advisability of their passing a resolution urging the Board of Trade to reconsider their determination; and he thought that if a copy of such resolution were sent to the Board of Trade it would have more effect than the memorial to which the Chairman had referred.

Major FLOOD-PAGE observed that the Chairman had said that the Board of Trade proposed to insist on the trade providing a cable which would cost thousands of pounds more than the older one, and be much less efficient. If that were so a question might be asked in the House of Commons (which could be easily managed) as to whether, before determining these questions, the adviser of the Board of Trade had had any practical experience of the carrying out of these things.

The CHAIRMAN said he had wires up now which he knew were not good, and he had, therefore, desired to put up some of the thin wire exhibited to the meeting. He had, however, been forbidden to do so.

Major FLOOD-PAGE proposed the following resolution:—"That this meeting of the Electrical Trades Section of the London Chamber of Commerce, feeling that if the Board of Trade insist upon their decision with regard to cables, as announced in their letter of the 30th ult., to Messrs. Crompton and Co., it will be seriously detrimental to the interests of the electrical trade, without providing additional protection to the public, earnestly solicits the Board of Trade to give their favourable reconsideration to Articles 9 and 12 of the rules and regulations for overhead wires, with a view to this decision being modified."

Mr. R. S. ERSKINE seconded the motion, which was carried unanimously.

Major FLOOD-PAGE said he thought they were hardly enough before the public, and he thought that the time had come when they might derive some advantage from a monthly *resumé* as to the condition of the electrical trade. They knew, for instance, that bullion merchants periodically informed *The Times* of the position of their trade; and the railway companies published their traffic returns weekly. He thought that the time had arrived when the electrical trade should publish similar information, which would be obtained from the various branches of the trade. No names would be published, the idea simply being that those interested might see periodically what was the value of the electrical trade in the United Kingdom. Every Monday morning particularly, he believed, *The Times* published a great deal of this kind of information, showing the position of various trades throughout the country. If similar returns affecting the electrical trade were forwarded to Mr. Trotter, that gentleman would be able to work up a summary, giving the information in question; and he thought that if such information were published, their trade might have a little more weight.

The CHAIRMAN said he thought the idea an excellent one, and the only point was how to give it effect.

Major FLOOD-PAGE said that this would require consideration. It was decided to form a small committee to consider the subject, and bring it forward at another meeting, the committee appointed being Major Flood-Page, Mr. Garcké, and Mr. Sharp.

The CHAIRMAN then read the following letter, which was forwarded to Mr. Murray on the 11th inst. by Mr. Garcké, Managing Director of the Brush Electrical Engineering Company (Limited):—

"Dear Sir: I have received your letter of the 7th instant. I do not know what there is on the agenda; but there is one matter which is coming prominently before us, and with regard to which I have written to Mr. Trotter; it is the question of whether contracting firms can come to any unanimity as to the terms upon which they should tender to local authorities who hold provisional orders. You will, no doubt, hear from Mr. Trotter as to whether he thinks there is any use putting this matter on the agenda, in which case I shall be happy to bring it forward."

Mr. TROTTER pointed out that the letter was received on the same day on which the notice of the meeting was sent out, and was therefore too late to be included in the agenda.

Mr. GARCKE stated that the matter arose out of the large number of Provisional Orders that were being obtained by Local Authorities. He thought that the terms upon which they should tender to Local Authorities would be a large question with manufacturers, and that it would be desirable if contractors could among themselves agree on the general lines on which this class of work should be done. He thought that if provincial authorities offered Orders, they should go a further step themselves, and do the work for which they had obtained powers.

In the discussion which followed, instances were given showing the onerous nature of the conditions sought to be imposed upon manufacturers by certain provincial authorities. In several cases the specifications had been returned by firms who had proposed to tender for this work, but who were compelled to decline to entertain the exorbitant demands and conditions which were imposed. It was suggested that a meeting of electrical manufacturers and contractors might be convened to consider the subject.

Mr. GARCKE observed that it was really a very large question in view of the attitude of the Board of Trade in encouraging provincial authorities to do the work.

Eventually a resolution was passed, on the motion of Mr. GARCKE, seconded by Mr. WHARTON, referring the question to the Committee of Electrical Manufacturers and Contractors.

The CHAIRMAN then expressed regret at having to announce that Lord Crawford had written to state that on account of ill health he did not think that he could retain the position of Deputy-Chairman of the Section. A letter had also been received from Mr. Weaver (who had been asked to serve on the Telegraph Committee) stating that the condition of his health would not permit him to undertake any other engagements at present.

The Insumgraph.—This is an instrument which by the aid of electric currents presents at a predetermined time a clear space of paper for signatures at an opening in a suitable desk, and at the end of the time of grace allowed moves it past the opening. The tell-tale and time-checking systems at present in use, owing to the fact that the necessary signals are made by electric currents set in motion by discs, or plugs, or press buttons, fail to ensure that the proper individual is actually performing his rounds. The insumgraph, however, by making an autograph necessary greatly diminishes the possibilities of fraud

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CHARLESWORTH, HALL, & CO.'S PROJECTOR PLANT.

The annexed engraving (Fig. 1) shows one of a number of Search Light Projectors, specially constructed by Messrs. Charlesworth, Hall, and Co., Oldham, for use on small vessels in the night navigation of rivers, canals, and narrow channels. The projector barrel

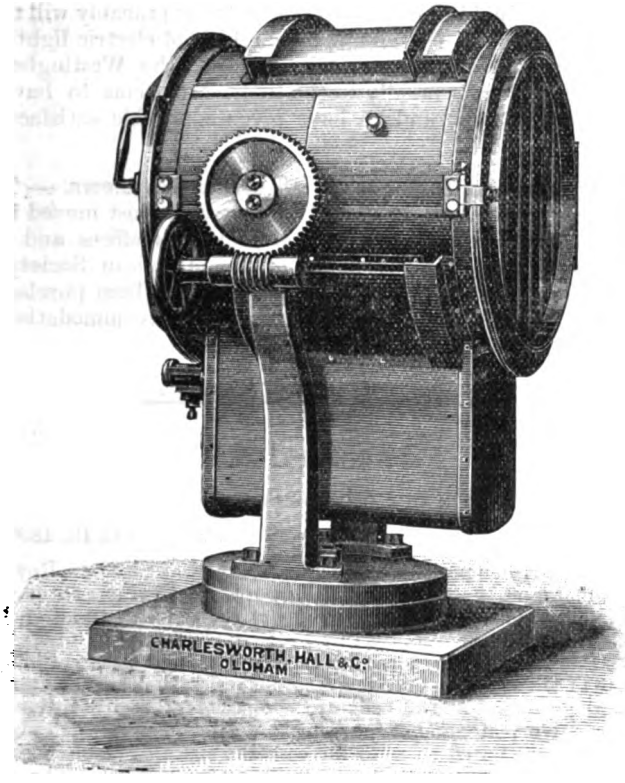

FIG. 1.—Charlesworth Projector.

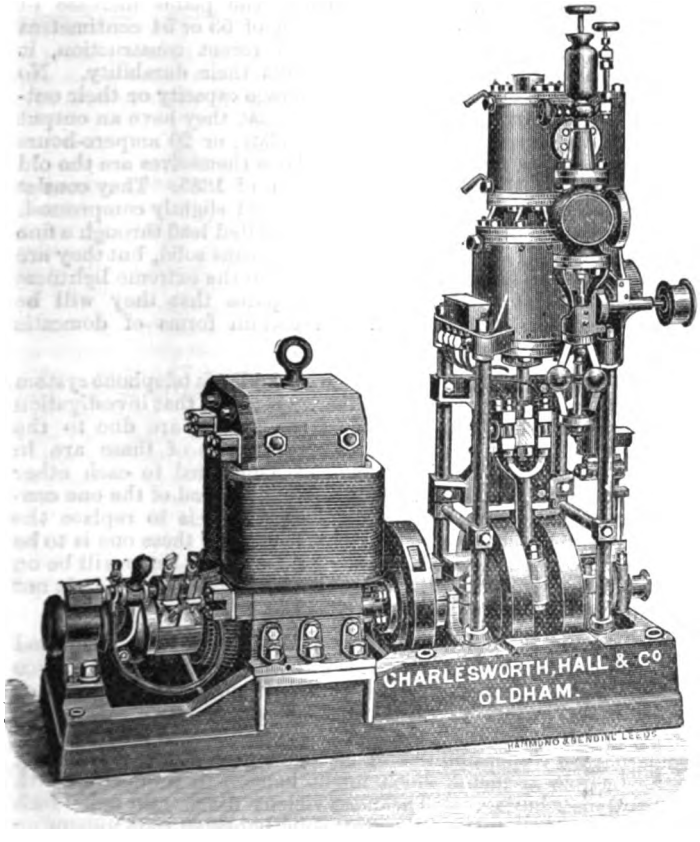

FIG. 2.—Charlesworth combined Engine and Dynamo, for working Projector.

is 16in. diameter, rolled out of steel sheet, and tinplated, making a very strong job. The mirror is Chance Brothers' best quality 16in. diameter, 8in. focus, fitted in a strong brass frame, with a bayonet socket attachment to the barrel to facilitate removal for cleaning, &c. A dispersing lens, also by Chance Brothers, having an angle of dispersion of 16deg., is attached by means of a hinged frame to the forward end of the barrel, in order to fantail the light so as to spread it on the banks. The arrangements for ventilation are very complete, both the mirror frame and projector-barrel being so arranged that a constant stream of cold air passes through, so preventing overheating of the mirror and destruction of the silvering. An instrument similar to a camera is provided at one side of the projector, for viewing the arc. The hand lamp is made detachable, and quite independent of the projector itself. The feed of the carbon is obtained by a right and left-hand thread screw in the usual way. A screw is provided for raising and lowering the carbons, and adjustments are arranged for setting the points of the carbons from below, without having to put the hand in the barrel. With carbons 20mm. diameter, and a current of 45 amperes, these projectors will illuminate a distance of about 1,200 yards.

Fig. 2 shows one of a number of very light and compact sets of electric light machinery, also made by Messrs. Charlesworth, Hall, and Co., specially suitable for ship lighting. One of these sets, as here shown, comprises an engine with cylinders 4in. and 5½in. by 4½in. stroke, driving a Hall dynamo direct at 500 revolutions per minute, with an output of 65 volts 50 amperes, the steam pressure being 60lb. per square inch. As will be seen, the engines are of the open frame type, the cylinders being supported on four steel columns, which also carry the crosshead slide. Both cylinders are fitted with piston valves, operated by one eccentric, the high-pressure cylinder exhausting direct into the low-pressure steam chest, so doing away with connecting pipe joints and stuffing boxes for the valve spindle. The pistons are steel castings fixed on one piston rod of Whitworth steel by means of cones and nuts. The piston-rod glands are tightened by screwed caps, so as to prevent galling, through one side being screwed more than the other, as sometimes happens with glands tightened with studs. A play of $\frac{1}{32}$in. is allowed in the gland for any slight bend in the piston-rod. The end of the piston-rod is passed through a cast-steel slipper slide block, and there screwed by two nuts which are pinned in position. This slide block has slips for taking up wear. The connecting rod is of cast aluminium steel. Both the large and small ends are of the usual marine type. The crank-shaft is of Whitworth steel, with circular crank webs and cast-iron balancing discs shrunk on. In order to reduce wear the crank-shaft and all other bearings are made of very large surface, and all parts can be lubricated while running. The dynamo is one of Messrs. Charlesworth, Hall, and Co.'s inverted type. The magnets are of best soft iron, tooled all over. The armature shaft is of Vickers' steel. The resistances are as follows:—Armature ·21 ohms, shunt 20·65 ohms, series ·0318 ohms, and giving an electrical efficiency of 79·6 per cent.

THE GERMAIN DRY CELL.*

The material made use of by M. Germain in his dry cell consists, as we have previously mentioned, of cellulose prepared from cocoa-nut fibre, which contains, besides pure cellulose, mineral salts, an organic colouring substance, and some fatty substances. The fibre is first of all treated by a process which deprives it of the fatty substances. It is then possible by various methods, which do not alter the physical nature of the fibre nor destroy the cellules, to obtain several kinds of cellulose, possessing greater absorptive and retentive properties than does cellulose in its natural state. These varieties of cellulose are not, moreover, affected by the active agents commonly employed in primary batteries. The particular variety of cellulose employed in dry cells is almost unaffected by ammonium chloride air or the ammonia to which the reaction of the Leclanché battery gives rise. Its apparent density is about ·06 to ·105. Without external pressure it absorbs from 10 to 11 times its own weight of liquid, and when subjected to a pressure of 100 grammes per square centimetre, it still retains 7·6 times its own weight of liquid.

The greater the compression of the paste the greater is the internal resistance of the battery, and with excessive pressures the resistance of the paste may amount to three to four times that of ordinary liquid. Some accumulators, however, furnished with this fibre have been found to have a smaller resistance than if liquid alone was employed. M. Meylan is of opinion that this is due to the fact that the accumulator plate is not a purely metallic electrode, but that it consists partly of oxides of relatively poor conductivity in a state of variable aggregation, and often making bad contact with the lead grid. The pressure of the fibre has the effect of ensuring a better contact; so that while the resistance of the electrolyte

* From *L'Electricien*.

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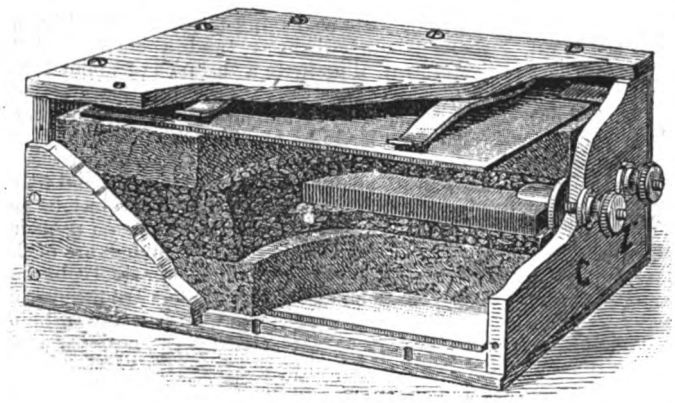
increases that of the plate diminishes, the diminution, however, being greater than the increase. In the particular case of the dry Leclanché cell, the effect of pressure is to ensure a uniform consumption of the zincs and to notably diminish the resistance of the mixture of carbon and binoxide of manganese, at the same time effecting more perfect depolarisation—phenomena which were observed some years ago by MM. D'Arsonval and Abdank-Abaknowicz. Moreover, the property which cellulose possesses of absorbing gases prevents the formation of a layer of gas on the surface of the electrodes. On the other hand, the evaporation of the liquid, if permitted, would give rise to non-conducting efflorescences, and at the end of a short time the battery would have such a high resistance that it would be no longer capable of being used.



The annexed figure represents an ammonium chloride dry cell, as arranged by M. Germain. The case is of oak, well boiled in paraffin, and rendered water-tight by a coating of tar. A zinc plate, which is well amalgamated on one side and varnished on the other, rests at the bottom of the box. The fibre is laid on the zinc plate layer by layer, having previously been saturated when warm with a solution of ammonium chloride (density 1·1) in the ratio of 1 by weight of cellulose to 3·5 or 4 of liquid. When this first layer is completed the carbon is placed upon it, surrounded with pieces of carbon and binoxide of manganese. A second layer of fibre is then laid upon the carbon, and upon this a plate of zinc. The wooden lid, to which are fixed several strong varnished steel springs, is then screwed down. The pressure usually employed is about 200 grammes per square centimetre, at which pressure the liquid slightly exudes against the zinc plates. The E.M.F. of the dry cell is uniformly 1·5 volts, the internal resistance varying, of course, with the size of the cells. Thus, a cell (Type B), $12 \times 7 \times 7$ centimetres, has an internal resistance of 1 ohm. The cell (Type G), which is 30 centimetres long, 20 centimetres broad, and 11 centimetres high, has an internal resistance of ·09 ohm, intermediate sizes having corresponding resistances.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 6, 1890.

The Consolidation of Electrical Interests.—Combinations and rumours of combinations seem to be the order of the day just at present. The latest combination is one between the Westinghouse and the Pullman interests. It is understood that Mr. Pullman acquires a large interest in the Westinghouse companies; and that by a united effort the Westinghouse electric railway business will be pushed vigorously to the front. Another rumour is in the air that a fourth great electric railway company will soon take the field, backed by no less a corporation than the Standard Oil Company. With an active management and the millions of the Standard Company behind it, there is a chance for pretty lively skirmishing in the railway business during the next few years. The details of this last organisation have not been made public. Besides this, the Julien Company is a party to an important storage battery traction combination, which will announce itself very soon.

The Electrical Situation in New York.—The electrical situation in New York is unaltered. The Board of Electrical Control, which has rendered itself obnoxious to electricians at large, has temporarily subsided, and there is no likelihood of immediate trouble from it. Meanwhile the ingenuity of divers inventors is being taxed to devise various subway systems suitable for use in the streets of New York.

New Systems of Lighting.—The Edison Company is making vigorous efforts to push its system of arc lighting for incandescent circuits. The Company possesses a lamp that is said to be thoroughly valuable for this purpose, and that probably will take its place as one of the prominent methods of electric lighting. Meanwhile the alternating arc system of the Westinghouse Company is coming rapidly to the front. It seems to have a great many friends, and to have given admirable satisfaction wherever it is used.

The American Institute of Electrical Engineers. — The American Institute of Electrical Engineers has just moved into new quarters on Thirty First-street. It has offices and will hold its meetings in the house of the American Society of Mechanical Engineers, which has but recently been purchased and fitted up with every convenience for the accommodation of a scientific society.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *June* 18, 1890.

Last week some public experiments took place with a new Reynier accumulator at the works of M. Durafort. M. Reynier, not having been able to prevent buckling in any of the ordinary types of lead plates hitherto employed, set to work to render buckling innocuous. With this view he now separates the electrodes by means of porous sheets of silica, which only increase the resistance of the cells to a very slight degree. The cells are composed of two positive and one negative plate, and of four sheets of silica, the two end sheets of silica being fluted so as to increase the space available for the electrolyte, the quantity of which, however, is small. The containing vessel is of sheet iron, lined with india-rubber, and it is therefore light and elastic. A battery of 20 elements is about 50 centimetres long; during discharge the plates increase in volume, the cells expanding till a length of 53 or 54 centimetres is reached. As the cells shown were of recent construction, it is impossible to say anything as regards their durability. No official test has been made as to their storage capacity or their output for weight, but the inventor asserts that they have an output of 30 ampere-hours per kilogramme of plate, or 20 ampere-hours per kilogramme of total weight. The plates themselves are the old lead plates of M.M. Reynier and Simmen, of 1885. They consist of very fine lead wires woven into a net, and slightly compressed. These lead wires are obtained by passing melted lead through a fine colander. The plates, so made, are by no means solid, but they are supported by the sheets of silica. Owing to the extreme lightness of this accumulator, M. Reynier anticipates that they will be largely used for traction work and certain forms of domestic lighting.

A Bill relating to the reorganisation of the Paris telephone system has just been laid before the Chamber. It states that investigation has shown that the grave defects of the system are due to the existence of twelve separate exchanges; most of these are in cramped situations, and all of them are connected to each other by an insufficient number of trunk wires. Instead of the one central exchange originally proposed the plan now is to replace the twelve existing exchanges by four new ones. Of these one is to be in the centre of Paris in the Rue Gutenberg, and three will be on the outskirts. Until this reorganisation has been effected it is not proposed to take on any new subscribers.

Recently, at the Conseil Municipal, M. Charles Laurant invited that body to come to an agreement with the Préfecture de Police with a view to enforcing the use of smoke-consuming furnaces or coke furnaces at the central lighting stations of Paris. The same worthy counsellor also demanded that rules should be drawn up regulating the responsibilities of electric supply companies, owing to the terrible accidents which might happen in connection with electrical distribution. "The most violent flash," said he, "such as is capable of destroying the most solid lightning rods measuring 2½ centimetres in diameter, has been estimated by scientists to be the result of an electric force of about 9,000 amperes. Now, to supply one single Edison lamp during one hour an equal quantity of electricity is necessary." The Conseil Municipal was much agitated at this startling statement, and immediately voted urgency.

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CORRESPONDENCE.

BICYCLES FOR TELEGRAPH MESSENGERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to your remark in *The Electrician* of May 30th, that bicycles would not be suitable for roughly-paved streets, it may be worth pointing out that with the so-called "pneumatic tyre," invented by Mr. Dunlop, of this city, riding on a pavement of "square setts" is much easier than on an ordinary macadamised road. The road is always more or less uneven, while the pavement is usually evenly laid; and the jar in passing over the separate stones is completely annulled by the elasticity of the tyre, a thick rubber tube inflated with compressed air. I weigh over 16 stone, and when on these tyres consider the tramway pavement a luxury.—Yours, &c.,

J. BROWN.

Belfast, June 16, 1890.

LEGAL INTELLIGENCE.

In Re Automatic Electric Railway Signal Company.

A petition to wind up this Company compulsorily, it being already in voluntary liquidation, came before Mr. Justice Stirling on Saturday last, the petitioners being Messrs. Blakey, Emmott, and Co. (Limited), the principal creditors, represented by Mr. Yate Lee. Their case was that the liquidator appointed under the voluntary liquidation was the secretary of the Company; and there was a probability of the patents belonging to the Company, which formed the main portion of the assets, and might turn out to be very valuable, being sold for a small sum to a syndicate, and thus the creditors would be left out in the cold. It appeared that the patents in question had been purchased by the Company for £75,000 in vendors' shares, and it was suggested that they would be sold for a very small sum to the Directors or their nominees.

Mr. BARDSWELL, on behalf of the Company, opposed the petition, and was supported by the other creditors, who were of opinion that it would be disastrous if a compulsory order were made. The liquidator denied there was any intention to sell the assets improperly. He was perfectly willing to give the petitioner all the advantages he would have if there were a compulsory order, and would undertake that no sale should be made without notice to the petitioner, or without the sanction of the Court.

In the result his Lordship said he saw no reason to remove the present liquidator, but he would make a supervision order, which he did not think would substantially increase the expense.

The Self-Winding Clock Company.

An application in the liquidation of the Self-winding and Synchronising Clock Company, which was ordered to be wound up on June 29th last, came before Mr. Justice Stirling on Saturday last, the object of which was to settle on the list of contributories three gentlemen named Crossfield, Bennett, and Myers. The liquidator found their names on the register, and accordingly put them on the list; but, on settling the list in chambers, they disputed their liability, and the summons was then adjourned into court. Mr. Whinney appeared for the official liquidator, and Mr. Onslow for Crossfield and Bennett; Mr. Myers did not appear.

Mr. WHINNEY said that the defence in each case was that they had been induced to take shares by misrepresentation, but no summons had been taken out or motion made to remove their names either before or after the liquidation.

His LORDSHIP, after hearing the evidence, ordered the three names to be retained on the list.

TRADE NOTES AND NOTICES.

TENDERS INVITED.—The Bishop's Stortford Local Board invite tenders for lighting the public streets of the district for one year, from August 16th next. Tenders are to be in by July 17th.

THE TELPHERAGE COMPANY.—Notice is given that the creditors of this Company are required by July 12th next to send in particulars of their claims against the Company to the liquidator, Mr. W. R. Pryor, 50, Old Broad-street, and, if required, are to come in and prove their claims.

INSTITUTE OF MEDICAL ELECTRICITY.—This Institute is removing from No. 24A, Regent-street, Waterloo-place, S.W., to No. 35, Fitzroy-square, W. The new premises will be occupied in about a fortnight.

MESSRS. WILKINS AND CO.—Messrs. Wilkins and Co., of the Submarine Telegraph and Wire Rope Works, Wapping, E., inform us that they have recently completed extensive improvements in their works, and rely upon their long-established reputation for excellence in material and workmanship to secure them extended orders for their manufactures.

MESSRS. J. E. H. ANDREWS AND CO. (LIMITED).—We have received from this firm a price list of the "Stockport" Gas Engine, in which illustrations are given of the new design double-acting engine without slide valve, and of the new vertical type engine. Stock sizes of these engines are from ¾ horse to 20 horse-power.

MESSRS. A. L. THOMAS AND SONS.—We have received from this firm illustrated particulars of their patent bush for fixing the ordinary bored pulleys and coupling to shafting, &c. By using this bush, pulleys can be fixed on shafting or spindles in less time than in the ordinary way; and the difficulty and expense of fixing ordinary pulleys upon shafting, which is often of full diameter in places and has to be reduced by filing or turning, is overcome by this device. The bush can be used on either rolled or turned shafting, and the pulley does not require to be taken off the shafting.

THE AMERICAN BELL TELEPHONE COMPANY.—The number of instruments in use by this Company on May 20th last reached the large total of 460,503.

THE THOMSON-HOUSTON COMPANY OF AMERICA.—The following statement of gross sales and profits of this Company, for the three months to April 30th last, is issued, and will be perused with interest:—

	1890.	1889.	Increase.
Gross sales	$2,133,099	$1,139,833	$993,266
Profits	$650,724	$299,613	$351,111
Motors ordered	1,106	247	859
Generators ordered	112	16	96

THE UNITED EDISON MANUFACTURING COMPANY OF NEW YORK.—We have received a well-illustrated pamphlet from this Company, giving detailed particulars of the Edison electric light system. The frontispiece to the pamphlet shows the very extensive machine works of the Company. Full descriptions are given of the Edison dynamo, ampere meter, pressure indicator, incandescent lamp, vases, standard sockets, double-pole switches, &c.; and following these descriptions is a copy of a circular containing a number of questions sent out by the Company to purchasers of their plant. The answers, in a large number of cases, are also given, and very great satisfaction is expressed by the various local companies whose central station plants have been put down by the Edison Company. The pamphlet also shows copies of testimonials from large users of the Edison system, and concludes with a standard specification for Edison electrical plants.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

May 24, 1890.

8,116. G. BINSWANGER and G. FRANKS. London. Improved handles for electrical switches.

8,144. E. J. PRESTON (on behalf of the firm of Stone and Company and E. W. de Rusett). London. Improvements in apparatus for lighting and ventilating ships' cabins and other places.

8,174. J. RICHARD and F. RICHARD. London. Electrical apparatus for transmitting to a distance the rotation of a signalling or indicating axis.

May 27, 1890.

8,233. W. A. A. DOWDEN. London. The extraction of gold from its ores, consisting of a form of copper plate amalgamated with mercury, the action of which, in retaining the gold upon it, is aided by the passing of a current of electricity.

8,241. C. L. JEFFERS. London. Improvements in electric lamp hangers.

8,242. W. R. LAKE. London. Improvements in and relating to electric-welding or metal-working apparatus (H. Lemp, United States).

8,253. J. KRIEGER, F. STITZEL, C. WEINEDEL, M. SCHWARTZ, A. REUTLINGER and J. H. EGELHOFF. London. Improvements in systems of circuits for electric semaphores.

8,254. R. HADDAN. London. Improvements in the manufacture of plates for electric accumulators.

May 26, 1890.

8,272. S. B. WILKINS. Edinburgh. Improvements in the construction of electrical fire or burglar alarms.

8,286. J. T. TODMAN. London. An improvement in electrical cut-outs.

May 29, 1890.

8,306. H. H. LAKE. London. Improvements relating to electric relays (E. F. Law, Russia).

8,325. J. M. A. PONCIA. London. Improved method of preventing injuries to submarine cables, which he designates "Chafe indicative alarm wires" (H. Kingsford, Peru).

May 30, 1890.

8,362. E. DUMMER. London. Improvements in electric locomotives.

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8,392. W. P. Thompson. Liverpool. Improvements in tubes or conduits for electric cables (Jacob Frères et Cie., France).

8,393. B. M. Drake, J. M. Gorham, and P. J. Pringle. London. Improvements in switches for electrical circuits.

May 31, 1890.

8,427. A. Apps. London. Improvements in electric arc lighting.

8,471. E. H. Morgan. London. An improvement in electrically driven locomotives.

8,474. C. A. McEvoy. London. Improvements in electrical switches.

8,477. S. F. Beevor. London. Improvements in electric switches or apparatus for making and breaking electric circuits.

June 2, 1890.

8,495. P. H. Williams. Egham, Surrey. Reducing speed of or stopping railway trains by magneto electricity, automatically or otherwise, and utilising the electricity by storage in accumulators for lighting or other electrical purposes.

8,528. B. J. B. Mills. London. Improvements in devices for transmitting power, and especially for transmitting power from electric motors used for the propulsion of vehicles (E. H. Johnson, United States).

8,534. N. de Bernardos and Lloyd and Lloyd. London. Improvements in secondary batteries or electrical accumulators.

June 3, 1890.

8,559. W. Rixom. Barnes. An improved electric wall plug or socket for connecting electric wires.

8,567. H. B. Cobb. London. Improvements in or relating to conductors and conduits.

8,578. J. Y. Johnson. London. Improvements in electric accumulators or secondary batteries, and in the manufacture and production of plates or elements therefor (C. Hering, France).

8,599. F. Anderson. London. Improvements in apparatus for the generation, distribution and commutation of electric currents.

June 4, 1890.

8,651. T. Smith. London. Improvements in casing for electrical conductors, cables, or the like.

June 5, 1890.

8,677. J. Garrow and C. Christie. Glasgow. An automatic machine for testing the strength of the wrist and muscles of the arms.

8,703. W. P. Thompson. Liverpool. Improvements in electric welding (C. L. Coffin, United States).

8,716. E. Edwards. London. A new or improved process for obtaining, by electrical decomposition, metallic zinc from solution of sulphite of zinc.

8,730. W. H. Miner. London. Electric soldering irons.

June 6, 1890.

8.754. T. A. Garrett and W. Lucas. London. Improved apparatus for protecting electric conductors from damage by lightning.

8,758. R. Collachi and N. Rolland. London. Improvements in electric generators.

8.777. H. H. Lake. London. Improvements in and relating to electric call-bells (P. Hathaway, United States).

8.778. H. Groswith. London. Electric motors.

June 7, 1890.

8,880. W. P. Thompson. Liverpool. Improvements in or relating to electric accumulators (Isaac Pearl, Spain).

8,853. A. Piat. London. Improved combined brake and circuit making and breaking device for use with electric motors.

8,854. L. A. W. Desruelles and K. F. O. Chauvin. London. Improvements in and relating to apparatus for measuring electrical energy.

June 9, 1890.

8,872. F. Suter. London. Improvements in electrical lamp holders.

8,892. A. Muirhead and C. R. A. Wright. London. A new or improved method of insulating electrical conductors and conduits for the same.

June 10, 1890.

8,933. G. H. Felt. Glasgow. Improvements in the method of and apparatus for depositing metals by electro deposition.

8,964. R. Kennedy. Kilmarnock. Improvements in electro-motors.

8,976. J. D. Case and C. W. Evans. London. Improvements in and relating to electrically operated musical instruments, and more especially of the piano type.

June 11, 1890.

9,028. S. H. Brooks. London. Improvements in arrangements and mechanism for stopping machinery when a thread or sliver, or other material operated upon, breaks or becomes absent, or when a given length has passed or a bobbin or spool is full, by means of electricity applicable to machines for preparing and spinning fibrous materials, and to other machinery.

9,030. C. H. Freedman. London. Primary battery for open-circuit work.

9,061. S. Z. de Ferranti and A. Wright. London. Improvements in electric meters.

June 12, 1890.

9,089. L. Henrie, H. Pückert, and Geo. Toennies. London. An unconsumable candle, an improvement on arc-lamp electric lighting.

9,124. Jean Jaques A. Aubert. London. An electric counter.

9,125. J. E. Kingsbury. London. Improvements in telephonic apparatus. (The Western Electric Company, United States.)

9,130. C. R. Heap and S. Sharp. London. Improvements in the means of and apparatus for the regulation of electric currents or their effects.

June 13, 1890.

9,138. H. A Bigland and J. Burns, Newcastle-on-Tyne. Apparatus for working electric light arc lamps and other electric appliances by means of twist rod or rods.

9,163. F. M. Newton and T. Hawkins, London. An improved automatic electrical switch or cut-out for use in connection with dynamos and accumulators to be charged thereby.

9,164. F. M. Newton and T. Hawkins, London. Improvements in electric switch boxes and switches.

9,165. F. M. Newton and T. Hawkins, London. Improvements in electrical switches.

9,166. F. M. Newton, London. Improvement in electric switches.

9197. P. P. Alexander. London. Improvements in electrical fuses.

9212. J. G. Statter and S. L. Brunton. London. A method of and apparatus for utilising fixed electro motors for elevating, hauling, and other like applications.

9227. H. Leak. London. Improvements in street and other lamps, also partly applicable to incandescent electric lamps.

9246. J. Ronczewski. London. An electro-magnetic separator.

9257. S. Wohle. London. Process for effecting electrolytic deposit of aluminium.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN

PHOSPHOR BRONZE.

PHOSPHOR BRONZE

BEARINGS, BUSHES,

AND OTHER PARTS OF

ELECTRICAL MACHINERY.

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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SPECIFICATIONS PUBLISHED.

1889.

11,847. SIEMENS BROTHERS AND COMPANY (LIMITED) (Siemens and Halske). Distributing electrical energy. (Price 8d.)

18,897. CUNNINGTON. Electric switch. (Price 6d.)

1890.

14,670. IMRAY (Gilbert). Electrical heating devices. (Price 8d.)

5,219. ANDERSON. Electric arc lamps. (Price 8d.)

6,120. KINTNER. Electric distribution. (Priec 8d.)

Amended Specifications.—1889.

11,328. CORRENS. Electric accumulators. (Price 6d.)

Second Editions.—1886.

4,664. THOMPSON (Cowles and another). Electric furnaces for aluminium, &c. (Price 8d.)

Third Edition.—1884.

14,233. HOPKINSON. Induction coils. (Price 8d.)

COMPANIES' MEETINGS.

Poole and White (Limited).

The statutory meeting of Poole and White (Limited) was held on the 13th inst., at the offices, 58, Bread-street, Cheapside.

Mr. JOHN TRYON, who presided, explained that the business had been in existence for about five months. It was originally contemplated to have for the present restricted the operations of the Company to the sale of goods manufactured for them by other firms. It was speedily found, however, that this arrangement would not be satisfactory, and they were now manufacturing entirely for themselves. The Directors believed that the property acquired by the Company, including the interest of Mr. White in his valuable inventions in connection with the manufacture of switches and other electrical apparatus, would result in good profits to the shareholders. It had been suggested by many people that the Company was nothing more nor less than a branch of Woodhouse and Rawson United (Limited). Such an idea was absolutely without foundation, the two Companies having no connection with each other beyond the ordinary business relations which existed between them and other electrical firms. Some pretext for this idea might perhaps have arised from the fact that Woodhouse and Rawson United (Limited) wished to manufacture for the Company; but such an arrangement would have been wholly impracticable.

The proceedings then terminated.

NEW COMPANIES REGISTERED.

ALLEN, EVERITT, AND SONS (LIMITED).—Objects: To take over as a going concern the business now carried on by William Edward Everitt at the Kingston Metal Works and the Stephenson Works, Birmingham, and in London and elsewhere, under the name of Allen, Everitt, and Sons, manufacturers of and dealers in copper and brass tubes, sheets, and wire, and yellow and other metal and brass founders, adopting therefor an agreement with the said William Edward Everitt, the particulars of which are not specified in the Articles of Association. Capital, £300,000, in £10 shares, of which 10,000 are Preference shares.

THE COLUMN PRINTING TELEGRAPH COMPANY (LIMITED).—Registered by Rollit and Sons, 12, Mark-lane, E.C., with a capital of £100,000, in £1 shares. Object: To acquire certain patents and rights in relation to printing telegraph machines, in accordance with an agreement, made June 5th, between Alexander M. Aitken, jun., of the one part and John Gennings, on behalf of the Company, of the other part. There shall not be less than three nor more than seven Directors. The first are the Right Hon. Earl of Wharncliffe (chairman), Viscount Lymington, M.P.; the Hon. A. Brand, W. H. Hurlburt, and Roderick Pryor. Qualification, £200. Remuneration: Chairman, £500; other Directors, £200 each.

DICK, KERR, AND CO. (LIMITED).—Registered with a capital of £160,000 in £5 shares. Object: To carry on business as manufacturers of rolling stock railway and tramway appliances, engines and machinery of every description, and as iron and steel founders and electricians, in accordance with an agreement, made May 31, between Frederick Manuelle and John Kerr of the first part, George Fleat of the second part, and G. W. Carr, on behalf of the Company, of the third part.

KENT PATENT ARC LAMP COMPANY (LIMITED).—Objects: To acquire rights in respect of inventions in connection with electric or other lighting or illuminating purposes, and in particular to adopt an agreement dated June, 1890, made with Mr. John Kent. Capital, £10,000 in £5 shares. Registered, June 13th, by Leslie, Antill, and Arnold, solicitors, 1, Gresham-buildings, London

TUBULAR FRAME WAGON COMPANY (LIMITED).—This Company was registered on the 6th inst., with a capital of £200,000, in £1 shares, 400 being Founders' shares, to manufacture railway and tramway wagons, cars and carriages, and to acquire inventions relating thereto, and generally to carry on business as civil, mechanical or electrical engineers. Solicitors: Messrs. Johnson, Budd and Johnson, 24, Austinfriars, E.C.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this Company for the week ended June 13, 1890, amounted to £4,571.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY (LIMITED).—This Company notify that the coupons due July 1st next on their Five per Cent. Mortgage Debentures will be paid on and after that date at the banking house of Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

GREAT NORTHERN TELEGRAPH COMPANY.—A half-yearly interim dividend, at the rate of 5 per cent. per annum, will be paid on July 1st next by Messrs. C. J. Hambro and Son.

THE HELIOS COMPANY.—The Helios Electric Light and Telegraph Construction Company, of Ehrenfeld, Cologne, which owns the Ganz Alternating-Current Patents for Germany, has increased its capital from 1,100,000 to 2,200,000 marks (£110,000).

WEST AFRICAN TELEGRAPH COMPANY (LIMITED).—At a Board meeting of this Company, held on Monday last, the Directors decided to recommend, subject to audit, a final dividend of 6s. 6d. per share, free of income-tax, in respect of the year ended 31st December, 1889, making, with the interim dividend of 3s. 6d. already paid, a total of 5 per cent. for the year. Subject to the approval of the meeting of shareholders, to be held on the 4th proximo, the dividend will be paid on and after that date. The transfer books of the Company will be closed from the 27th June to the 4th July, both days inclusive.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts of this Company for the half-month ended June 15th show an increase of £124 as compared with the corresponding period of last year.

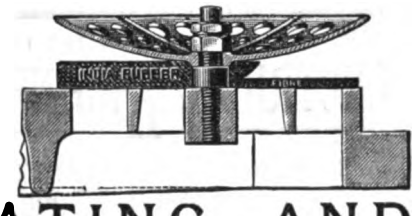
WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended June 13, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,543.

WESTINGHOUSE ELECTRIC COMPANY.—The stock of this Company is to be increased $3,000,000, or from $5,000,000 to $8,000,000. Mr. George H. Pullman is to take the entire issue at par, or $50 a share.

WOODHOUSE AND RAWSON UNITED (LIMITED).—We are asked to deny the statement made in a financial contemporary that the Chairman of this Company has resigned, in which statement we are informed there is no truth.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 20th Sept. 1886.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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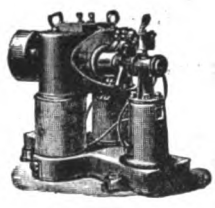
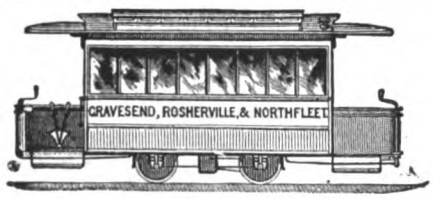
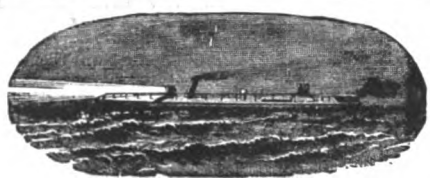
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 11.	Price Wednesday, June 18.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 18. Highest.	Lowest.
£			**TELEGRAPHS.**			£ s. d.			
1,381,380	Stock	12/6	Anglo-American	50½ 51½	50½ 51½	5 6 10	Jan., Apr., July, Oct	.. ..	.. ..
2,809,310	Stock	25/0	Do. Preferred	87 88	87 88	6 5 0	,, ,,	87¾	87⅝
2,809,310	Stock	..	Do. Deferred	15¾ 16¼	15 15½	..	February	15 7/16	15
25,000	£100	4%	African Direct, 4 per Cent. Debentures	98 101	99 102	3 18 5	January and July	100⅜	..
130,000	10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	6 2 5	Mar., June, Oct., Dec.	12⅛	11¾
69,200	100	5%	Do. 5 per Cent. Bonds	101 103	101 104	4 17 1	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	106 109	106 109	4 11 9	June and December	..	..
..	$100	..	Commercial Cable	106 106½	104¼ 104¾	..	..	..	..
16,000	£10	9/0	Cuba Submarine	11¾ 12¼	11¾ 12¼	7 6 11	February and August	..	..
6,000	10	10%	Do. Preference 10%	17⅛ 18⅛	17 18	5 11 1	,, ,,	17½	17
12,931	5	2/4½	Direct Spanish (£4 paid)	3⅜ 4⅛	3⅜ 4⅛	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October	9⅜	..
60,710	20	3/6	Direct United States	10½ 10⅝	10½ 10⅝	6 14 11	Jan., Apr., July, Oct.	10 5/16	10½
400,000	10	2/6	Eastern	13¾ 14	13⅞ 14⅛	4 12 0	,, ,,	14⅜	13⅝
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	,, ,,	..	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	107 110	105 108	3 14 1	May and November	106½	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	108½	..
250,000	10	6/6	Eastern Extension	13¾ 14	14⅛ 14⅜	4 17 5	Jan., Apr., July, Oct.	14 3/16	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101 103	101 103	5 16 6	February & August	103	101½
91,800	100	5%	Do. 5 per Cent. (Austin. Gov. Sub.) Debs. 1900	103 106	104 107	4 13 6	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	,, ,,	104½	..
180,227	10	2/0	Globe Telegraph and Trust	8⅞ 9⅛	8⅞ 9⅛	5 9 7	Jan., Apr., July, Oct.	9 1/16	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅜ 15⅛	14⅜ 15⅛	3 19 4	,, ,,	15⅛	14⅜
150,000	10	5/0	Great Northern	15⅜ 16⅛	15⅜ 16⅛	4 12 4	Jan., July, and April	16⅛	..
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102 105	102 105	4 15 3	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	37 39	37 39	6 8 2	April and October	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 15 9	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7¾ 8¼	7¾ 8¼	6 1 3	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	112 116	112 116	..	,, ,,	114½	114
15,609	£10	5%	West African	9 10	9½ 10½	..	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99 102	99 104	4 18 0	March & September	100½	99
30,000	10	2/0	West Coast of America	6½ 7	6½ 7	8 11 5	January and July	7	6 13/16
150,000	100	8%	Do. Debentures 8%	111 116	111 116	6 17 11	June and December	112½	112½
88,321	10	Nil.	West India and Panama	2⅜ 2⅝	2⅜ 2⅝	..	..	2 7/16	..
34,563	10	6/0	Do. 1st Preference 6%	11 11½	11 11½	5 4 4	April and October	11½	11⅜
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12½ 13½	12½ 13½	..	..	..	..
64,572	15	6/0	Western and Brazilian	9¾ 10¼	10 10½	5 14 4	May and November	10 1/16	10
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6¾ 6¾	6½ 6¾	..	..	6⅝	6⅝
26,986	7½	4/6	Do. 5 per Cent. Deferred	3½ 4	3½ 4	..	..	3½	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106 109	106 109	5 10 1	..	107	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104 107	104 107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99 101	99 101	5 18 10	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5¾	Consolidated Telephone Const. and Maintenance	⅛ ⅜	⅛ ⅜	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼ ⅜	¼ ⅜	4 8 3	Yearly	..	..
386,875	5	3/0	National	5¾ 6	5¾ 6	..	June and December	6	5 13/16
49,925	5	1/4½	Do. New	5½ 6	5½ 6	..	..	5½	..
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference	12½ 13	12¼ 13	4 12 4	June and December	12⅞	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference	10¼ 10¾	10¼ 10¾	..	,, ,,	10⅜	10⅜
209,750	1	..	South of England, Ordinary	¼ ..	¼ ..	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3½ 3¾	3½ 3¾	..	..	..	..
55,000	5	2/0	United River Plate	4⅜ 5	4½ 5	..	January and July	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	2¼ 3	2⅜ 2⅞	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5¼ 5¾	5¼ 5¾	..	..	..	..
42,853	5	..	Westminster Electric Supply	1¾ 2¼	1¾ 2¼	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	2⅝ 2⅞	2⅝ 2⅝	..	..	2⅝	2⅜
63,416	2	1/2	Do. Preference	1⅝ 2⅛	1⅜ 2⅛	5 12 11	..	..	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares	5¼ 5¾	5¼ 5¾	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction	9¾ 10¼	9¾ 10¼	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	4⅜ 5¼	5 5⅛	..	..	5 1/16	5
20,000	5	..	Fowler-Waring Cables	2⅛ 2⅜	2¼ 2⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	19½ 20½	19 20	5 0 0	February & August	20¼	19⅝
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5¼ 5⅜	5¼ 5⅜	3 13 0	..	5⅜	5½
37,350	12	36/0	Telegraph Construction and Maintenance	44 46	44 46	5 3 11	March and July	45	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101 104	101 104	4 16 2	..	..	..







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THE ELECTRICIAN:

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NOTES.

The startling announcement made by the Postmaster-General, that the Government have decided not to purchase the undertakings of the Telephone Companies, is of too great importance to be dealt with in a short editorial note; but one thing may be briefly said of the decision at once, namely, that it is as disappointing as it was unexpected. Although one of the two telephone patents expires in December of this year, and the remaining patent in the following May, the patentee's license to work them runs for another twenty years. There will, therefore, presently be created the unprecedented novelty of a virtual monopoly being worked without any legal patent, or else that of an unrestricted competition being carried on against a virtually legalised monopoly. One other alternative, indeed, is open to the Post Office Telegraphs, that of becoming sole competitor with its own licensee, which perhaps would be the greatest novelty of all. From whatever point of view the future is now regarded, it is beset with complications of most serious moment for all the parties concerned.

The immediate cause of the unfortunate fire which occurred last Saturday at the house of Mr. R. D. Sassoon is, as usual in such cases, somewhat obscure. The casings and wooden-backed switches were, so we hear, run in new plaster; and investigation now shows that for some time past a gradual breaking down of the insulation had been going on, resulting in the establishment of a general leak. The section of the battery which is discharging on to the house lamps is not, so we understand, always disconnected from the charging main; so that an earth, on a house circuit, coupled with another on the charging main, might give rise to unpleasant consequences. According to one informant, "electric sparks were seen all over the house" at the time of the occurrence, a phenomenon which, if it is accurately described, would point to the presence of a high potential current in the house circuit. On the other hand, the Cadogan Company state that careful tests of their circuits showed nothing wrong, and that the charging of the remaining batteries was renewed without difficulty soon after the fire occurred. Whoever is to blame we trust we shall have no more of these unfortunate mishaps, a few of which would completely neutralise the confidence in the electric light which the good work of the past few years has in so large a measure restored.

At the meeting of the Physical Society on Friday last, the results of an important research on the measurement of electro-magnetic radiation were experimentally shown by Mr. Vernon Boys. It will be remembered that Mr. Gregory some time since succeeded in measuring the expansion of a fine wire caused by the heating effect of the electrical oscillations set up within it; and, with the view of confirming this result, Mr. Boys has employed two distinct methods, the application of which has needed great ingenuity and manipulative skill. One of these methods, depending on the mechanical forces exerted between two adjacent wires in which oscillations were induced, appeared at first to succeed, owing to an extraneous effect; but after this had been carefully eliminated, no action could be detected, although the adjustments were delicate enough to indicate a force of less than a one hundred-millionth part of a grain. This failure may be partially attributed to the mutual influence of the oscillations in the two closely adjacent wires, since, owing to the difference of phase so caused, the force between them would be lessened. There is, however, good reason to believe that with the increased delicacy obtainable by employing parabolic reflectors, measurements of this force may yet be successfully made; and, if so, many problems in electrical theory may then be solved. Hitherto measurements in connection with electric oscillations have only been of the roughest kind, but, as soon as a satisfactory method of measurement is found, we may reasonably look for the experimental solution of many questions about which the mathematicians at present dispute with huge armies of symbols; and we may expect that the simplification of our ideas brought about by the solution of these problems will be of service in practice as well as theory.

The second method used by Mr. Boys depended on the use of a modification of a very delicate thermometer invented by Joule, and after some trouble this was made to succeed. The result found was in perfect accordance with that of Mr. Gregory, and the heating effect caused by the electric oscillations is thus conclusively established. The discussion which followed the reading of the Paper was of considerable interest; and Sir W. Thomson, while agreeing in the main with Mr. Boys' views, pointed out that with electric oscillations, in which the duration of the forces is so short as to be comparable with the time taken to propagate them, it was impossible to distinguish the electro-static from the electro-dynamic forces. The law of action between rapidly moving charged bodies is, in fact, not understood, and is one of those

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problems which may be solved by methods similar to those used by Mr. Boys.

We publish this week a method, due to Mr. Brew, for determining the self-induction of a coil by means of a Cardew voltmeter. The method is of some interest, since it requires very simple apparatus; it is, however, of limited application, for an alternating potential of known frequency must be available, and the coil to be tested must be capable of standing the currents and potentials for which the Cardew voltmeter is used. The variation of the resistance of the voltmeter with the magnitude of the current will not be any serious disadvantage when the impedance of the coil is as large or larger than that of the instrument, except in the few cases when very accurate measurements are required.

M. Gouy, who has already devoted considerable time to the study of the law of the quadrant electrometer, has recently given his attention to the use of that instrument for ballistic purposes. From the account of his work, which we publish in another column, it will be seen that an encouraging amount of success has been obtained with an electrometer whose needle was suspended with a fine wire, and whose oscillations were undamped except by air friction. A good ballistic electrometer would be a very valuable instrument for many purposes, some of which are so obvious that they have probably occurred to others as well as M. Gouy. The difficulty of making a satisfactory instrument has, however, hitherto been too great for experimenters to surmount; and M. Gouy may therefore be congratulated on the skill he has shown. Practical electricians look upon electrometers with rather too much awe, as instruments whose delicacy renders them only fit for laboratory use. Until quite recently, little time has been devoted to them since Sir W. Thomson first introduced the quadrant type, and, in consequence, but few improvements have been made. If they had been as much studied as galvanometers, we might now be in possession of an instrument which could, like the D'Arsonval type of galvanometers, claim, at the cost of some degree of sensitiveness, the much more desirable qualities of ease and certainty of working. The need of instruments for alternate-current measurements has redirected Sir W. Thomson's attention to the improvement of electrometers; and the valuable results of his efforts are well known. We are, however, of opinion that there is a much more brilliant future for electrometers than their use at present gives any indication of, and the communication of M. Gouy clearly shows a new series of useful applications.

We have received from the Weymersch Battery Syndicate the copy of a lengthy report on some tests of this battery recently undertaken by Messrs. Alabaster, Gatehouse, and Co. We published some two years ago a similar report upon the same battery by the same authorities; and the *raison d'être* for this second document is not very apparent, since the main differences between the conditions of 1888 and those of the present date consist in the diminished size of the cells, the substitution of porous plates for pots, and some slight variation in the strength of the exciting and depolarising solutions.

These tests, however, at the same time that they prove the depolarising solution compounded by M. Weymersch to be a good one, show what a very limited field in reality lies open to a primary battery intended for what may in this connection be termed heavy work. Even if we suppose that the depolarising solution is to be sold at the lowest possible price, and take into consideration only the cost of materials, 1,000 watt hours supplied by a Weymersch battery still cost 1s. 6d., as against the 6d. to 10d. charged by an electrical supply company. It will be urged, no doubt, that it is just where there are no electrical supply companies, and where large installations are not warranted, that there is room for a good primary battery. For dentists' motors, miners' lamps, and amateurs, primary batteries have their uses; but for ordinary house-lighting, unless the inventors of these secret solutions will also undertake to supply competent domestics, a Bunsen cell, however modified, is not likely to meet with any great demand. The everyday manipulations which a battery such as the one in question requires are quite beyond the resources of the small houses for which its capabilities alone fit it. To keep only seven 16 candle-power lamps burning during a winter's evening it would be necessary every day to handle, taking out exhausted and pouring in fresh liquid, 42 gallons of dilute sulphuric acid, and every fourth day 22 gallons of depolarising solution. Unless, therefore, the extended use of primary batteries results in the evolution of a new form of domestic servant, this consideration alone seems to us to preclude the idea of any extensive demand for primary batteries for house-lighting even on the smallest scale.

Honours to M. Gramme.—The Société d'Encouragement has awarded the Ampère medal to M. Gramme.

Zürich.—An electric tramway on the overhead wire system, 2·5 kilometres long, is to be built at Zürich. Water power is available.

Steno-telegraphy.—M. Cassagnes' steno-telegraphic instrument has been placed in the Museum of the French Postal Telegraph department.

Cambridge.—The Town Council have appointed Dr. J. A. Fleming to advise them on the best way of carrying out the electric lighting of the town.

Cardiff.—At the last meeting of the Lighting and Electrical Committee of the Corporation it was decided to recommend the Corporation to apply for an electric lighting Provisional Order.

Troyes.—On Saturday last the central lighting station of the Compagnie Nationale d'Électricité was inaugurated. According to the *Bulletin Internationale de l'Electricité*, M. Ferranti was present at the ceremony.

Electric Lighting Acts Amendment (Scotland) Bill.—This Bill passed through Committee in the House of Commons on Thursday last week, and was read a second time in the House of Lords on Wednesday last.

Leeds.—The deputation from the Electric Lighting Committee of the Leeds Corporation has returned from London; and a report will shortly be presented to the full committee, and afterwards to the Council.

The Telephone in Spanish Colonies.—By a recent royal decree the Minister of the Colonies has been authorised to make concessions for telephonic services in the islands of Cuba, Porto Rico, and the Philippine Isles.

Valencia.—A Central Station has been erected at Valencia by Mr. Ramon Cases, head of an electric light company at Madrid. Örlikon dynamos are used, and the lamps, &c., are supplied by the Allgemeine Elektricitäts-Gesellschaft.

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Edinburgh Exhibition.—On Saturday last the Lord Mayor of London visited the Exhibition, and after examining several of the Sections he opened the telpher line, and said he hoped the invention would be very much taken advantage of by the public.

The Tudor Accumulator.—According to the *Electrotechnisches Echo*, the Allgemeine Elektricitäts Gesellschaft and Siemens and Halske intend to erect a factory for the manufacture of Tudor accumulators in connection with Müller and Einbeck, the present makers.

Electrical Trades' Section River Excursion.—Some difficulties have arisen in arranging this excursion, owing to the regulations for the Henley regatta. Nearly 60 places have been applied for. Applicants will be informed as soon as definite arrangements are made.

Brighton.—The Town Clerk has received a communication from the Local Government Board, sanctioning the borrowing of the necessary money for carrying out the electric light works at Brighton. The sums required are £32,500 for the electric lighting, and £4,500 for the store yard.

Weston-super-Mare, Clevedon, and Portishead Tramway Bill.—This Bill, the object of which is to obtain extension of time for the construction of works, and to authorise the use of electricity on the tramway system, was passed last week by a Committee of the House of Commons.

Barmen.—According to the *Gas World*, the electric light in this town has produced favourable returns, while at the same time the gas consumption has so greatly increased that a new gasholder, of a capacity of 530,000 cubic feet, is urgently required, and is being got ready for the autumn.

The Thomson Alternate-Current Motor at the Royal Society Soiree.—It may be worth mentioning that the Thomson alternate-current motor, which attracted so much attention at the Royal Society *soirée* last week, was actuated by a current generated by the Ferranti alternator at Deptford.

Electrical Execution.—It has been decided by the Court of Appeals of the State of New York that Kemmler is properly in the custody of the warden of Auburn Gaol. The sentence of execution by electricity passed upon him will therefore be shortly carried out unless further legal complications arise.

The Peral Submarine Torpedo Boat.—The Spanish Government has, on the proposal of the Minister of Marine, conferred a title of nobility upon Lieutenant Peral, of submarine boat fame, and presented him with £20,000 for services to his country, and as a testimony of his countrymen's gratitude.

The Fritsche Dynamo.—In some tests of this machine recently undertaken by Herr Uppenborn, he states that he ran an 8-pole machine, giving an average of 112 volts 177 amperes at 180 to 182 revolutions for three hours, and found the rise in temperature of the armature to be 14·7°C., and in the field magnets 19·0°C.

House of Lords.—A Select Committee, presided over by Lord Belper, on Thursday last threw out the Bill recently passed by the House of Commons, authorising the Whitehaven Gas Company to extend the limits of their supply, to erect works, and supply electricity, and to raise £25,000 additional capital for this purpose.

The Ward Electrical Omnibus.—On the return of the Lord Mayor from Edinburgh he was met at Euston by the electrical omnibus owned by the Ward Electrical Car Company. The omnibus, which was driven by Mr. Radcliffe Ward, the managing director, conveyed his lordship and the Town Clerk to the Mansion House.

Insuring Employes.—The Detroit Electric Light and Power Company has adopted a plan of insuring its employés, every one of whom carries a $5,000 policy, the premiums upon which are paid by the Company so long as he is in its employ. The arrangement insures the employé's family in case of accidents, and protects the Company from damage suits.

Press Rates in Hungary.—The Hungarian Minister of Communications, M. Baross, proposes to reduce the telegraph tariff for Press messages from 2 kreuzers to 1 kreuzer per word. For the present, however, this reduction will only be granted to newspapers which receive 60,000 words per annum from Hungary, and which will deposit a guarantee for so doing.

Telephonic Communication between Belgium and Germany. The Telegraph Departments of these two countries have again taken up the question of establishing telephonic communication between Brussels, Verviers, Aix-la-Chapelle, and Cologne. In Belgium the wire has already been taken to Welkenraedt on the German frontier, and it only remains for the gap between Welkenraedt and Cologne to be bridged over in order to complete the line right through.

Telegraphs in the Dutch West Indies.—The Dutch Government, says *Industries*, has impounded the caution money deposited by the Pedro Segundo Telegraph Cable Company, of New York, which has failed to carry out its contract for the laying of a cable connecting Paramaribo, the capital of Surinam, with Cuba and Florida, *viâ* Curaçoa. The same contract, or a similar one, has now been undertaken by the Compagnie Française des Télégraphes Sousmarins, in Paris, against a Government subsidy of £2,000 per annum.

A Destructive Flash.—During a recent storm at Playford, Suffolk, a poplar tree, about 300 yards away from the church, was struck by lightning, and the bark was completely stripped from top to bottom, the southern half of the body being riven into matchwood. One piece, 5½lb. in weight, was picked up 126 yards away from the tree, and the *debris* covered about two acres of land. The discharge left the tree at the foot, following the direction of a fence for about 15 or 20 feet, threw up a sod about a foot square, and went to earth.

Electric Lighting in Victoria.—Electric lighting, it would seem, is a very profitable business in Victoria. At the first half-yearly meeting of the A. C. Alcock Electric Light and Motive Power Company, the Chairman stated that but for the fact that the Directors had decided to allow 10 per cent. instead of 5 per cent. for plant depreciation, the Company would have been enabled to show a profit at the rate of 20 per cent. per annum for the six months. What the rate of profit was, however, when 10 per cent. was allowed for depreciation does not appear.

The Breakage of Submarine Cables.—The suit of the Western Union Company against the Inman Steamship Line was decided on Tuesday last in the United States Court. The decision was against the Western Union Company. The suit was brought for breakage of telegraph cables by the propeller of an Inman Line steamship becoming entangled in them. The steamship company filed a counterclaim for 2,000 dollars, damages done to the ship's propeller. The Court allowed this counterclaim. Presumably the cable was attached to a buoy the position of which was not properly indicated.

The Reverchon Watchman's Signal.—An ingenious electric signal for a factory watchman, worked on a single circuit, is described in a recent number of *Cosmos*. The arrangement consists of a single wire, with its return going in series to each post. At every post there is a commutator, the movement of which by the man on his rounds throws in a fine wire resistance. At the office there is a revolving drum, on which an ink needle attached to a galvanometer traces a mark. As each successive resistance is switched in, the deflection varies and leaves a trace of the time of the watchman's signal.

The Electrical Purification of Sugar Juices.—Some sugar works in Havana have recently been provided with purifying plant in which osmosis and electrolysis simultaneously are at work. The sugar juices are poured into the middle compartment of a series of troughs, which are divided into three by two porous partitions. The outside compartments contain water, in which are placed blocks of carbon connected to the negative pole of a dynamo. The positive pole of the machine is connected to carbon plates in the middle compartment. The sugar juices are purified from the salts they contain, which are taken up by the water. The addition of the current seems to assist the osmotic transfer across the porous partitions.

The Protection of Linemen.—An arrangement for the prevention of accidents by the electric current has been adopted at the works of the Morgan Engineering Company, of Alliance, Ohio. A board is fixed on the wall facing the dynamo in the engine-room. On this board are six hooks for the checks of the six men who are employed in looking after the circuits. When a man is called on duty he removes his check from the hook

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and takes it with him. The engineer sees by a glance at the board that one check is absent, and that, therefore, one man is engaged about the lines around the shop, and the dynamo is not started until the check is replaced on the hook.

Metropolitan Provisional Orders.—The Board of Trade have granted Provisional Orders to the House-to-House Electric Light Supply Company for a portion of the parish of St. Mary, Lambeth, the parish of Islington, and the district of the Wandsworth Board of Works, comprising the parishes of Wandsworth, Clapham, and Putney. A Provisional Order has also been granted to the St. James's and Pall-mall Electric Light Company for the parish of St. James's, Westminster, and to the London Electrical Supply Corporation for an area comprising the whole of the parish of St. George-the-Martyr, Southwark, together with a portion of the parish of Camberwell.

The Lightning Conductor Question in Germany.—The *Electrotechnische Zeitschrift* of June 13th contains the report of a long Paper by Dr. Neesen on the interminable question, "Should lightning conductors be in metallic connection with the gas and water pipes or no?" This is a subject which seems to have an irresistible attraction for the German mind; and for the last two years or so the technical papers have never been free from it. In connection with the Paper it is mentioned that the *Electrotechnische Verein* would be glad to receive accounts of lightning strokes bearing on the subject. They should be addressed to Herrn Prof. v. Bezold, Kgl. Meteor. Institut. Berlin, W., Schinkelplatz 6.

Folkestone.—At the last meeting of the Town Council, the Electric Light Committee reported that they had had an interview with the representative of Messrs. Crompton and Co. upon the question of their contract to light the town by electricity. The Committee stated that it was very unsatisfactory, and it was decided to bind them to their original contract. Councillor Thompson, in moving that the report be received, said as they were unable to enter into any arrangement to have the light produced within any reasonable time they came to the determination that the only course was to hold them to the original contract—that the light be supplied by the 1st July. The report was received without comment.

The Kensington Vestry.—At the last meeting of this Vestry the Works Committee reported that they had considered as to the great amount of extra work devolving upon the surveyor in connection with the supervision of works being carried out by the several electric lighting companies within the parish, and had ascertained from him that the companies were prepared to pay him a reasonable sum to compensate him for the additional work which he is called to carry out. The Committee therefore recommended that the surveyor be authorised to accept such compensation from the electric lighting companies, subject to his reporting to the Committee from time to time the amount which he has received from them.

Greenwich Observatory.—We extract the following notes about Greenwich Observatory from the report of the Astronomer Royal to the Board of Visitors:—"The continuous registration of meteorological phenomena has been maintained as usual, and all the instruments are in good order. The Thomson electrometer, which had been out of order since the autumn of 1888, was finally adjusted by Mr. White, of Glasgow, and brought into use again in October, 1889, the amplitude of motion of the spot of light being increased more than two-fold. The automatic drop of the Deal time-ball failed on 21 days owing to interruption of the telegraph connections, and on one day high wind prevented the raising of the ball. There have been frequent failures in the return signal, the arrangements for which are not in a satisfactory state.

The Cost of Transmitting Power.—The following comparisons of cost of transmission of power by various methods appeared in the *Revue Universelle des Mines*:—(1) Comparative cost of 10 horse-power transmitted 1,093 yards: By cables, 1·77 per effective horse-power hour; by electricity, 2·21; by hydraulics, 2·90; by compressed air, 2·98. (2) Comparative cost of 50-horse power transmitted 1,093 yards: By cables, 1·35 per effective horse-power hour; by hydraulics, 1·87; by electricity, 2·07; by compressed air, 2·29. (3) Comparative cost of 10 effective horse-power transmitted 5·465 yards: By electricity, 2·64 per effective horse-power hour; by compressed air, 4·66; by cables, 4·69; by hydraulics, 5·29. (4) Comparative cost of 50 horse-power transmitted 5,465 yards: By electricity, 2·37 per effective horse-power hour; by cables, 2·65; by compressed air, 2·99; by hydraulics, 3·02. Steam was the prime mover used in each of the above instances.

The Underground Telephone Lines at Hamburg.—The first underground telephone lines at Hamburg were laid down at the end of last year. The cables are formed of 28 strands, arranged in seven groups of four 1mm. wires. This is lapped with three coverings of cotton, and to overcome induction there is a tinfoil coating connected to a 1mm. diam. copper wire leading to earth, there being one of these earth wires to each group. The cable wires are then coated with prepared tape, over which is a lead sheath. This is covered with a layer of asphalted tape. For the protection of the cable it is covered with 19 tinned iron wires of trapezoidal section 4·7mm. by 4·3mm. by 1·7mm. The diameter of the finished cable is 3·2cm., and the weight per metre 4 kilos. These cables are laid in cast-iron troughs. The covers of these troughs are generally 60cm. below the level of the street. In all 79 cables, having a total length of 30,000m., have been laid.

Jerritt's Military Field Sounder.—This apparatus, which has been devised by Mr. Jerritt, of Plymouth, consists of a small instrument so arranged as to be capable of being used as a transmitter and receiver. By an ingenious arrangement, the lever of the sounder is employed both for sending and receiving messages, thus doing away with the ordinary apparatus for transmitting telegraph work, the current being put on and off by means of a small switch fixed to the base of the instrument. A telephonic arrangement can be adjusted for receiving purposes if required. The instrument, battery, sounding-box, and telescopic stand fold up and form a compact knapsack, and can be comfortably carried as such by any operator. The centre of the stand, it may be mentioned, can be used if necessary as a drum for winding a quantity of wire. The apparatus should prove of use for military purposes, or working parties while erecting telegraph lines for communicating messages to the nearest transmitting station.

The Gilbert Club.—A joint meeting of the Essex Field Club and the Gilbert Club will be held at Colchester on Saturday, July 5th, with the object of affording to members of these Clubs, and any ladies and gentlemen interested in the history of science, and the parts filled by Englishmen in its inception and progress, an opportunity of visiting the birth-place, death-place, and last resting-place of William Gilbert. The party will visit Gilbert's house (anciently known as "Tymperleys" or "Tympornellis"), by kind permission of the owner, and Holy Trinity Church, where is Gilbert's monument. The chair at luncheon will be taken by Lord Rayleigh; and in the evening the Mayor (Mr. Asher Prior) will receive the Societies at the Town Hall at 7-30 p.m. During the evening Prof. Silvanus Thompson will give a lecture on "The Early Magnetic Experiments of Gilbert of Colchester." Anyone wishing for further particulars should apply to Mr. William Cole, Buckhurst Hill, Essex, Hon. Sec. Essex Field Club.

The Edinburgh Meeting of the Institution of Electrical Engineers.—The following circular has been sent round by the Secretary, Mr. F. H. Webb, in connection with the Edinburgh meeting of the Institution:—

Dear Sir,—I beg to inform you that, in compliance with a request of a deputation from the Executive Council of the above Exhibition, an extraordinary general meeting of the Institution will be held at Edinburgh on July 15th, 16th, and 17th next. Among the Papers to be read, in the lecture hall of the Exhibition, will be the following: "On some of the Chief Features of the Exhibition, and mainly of the Electrical Section," by Prof. Robert M. Walmsley, D.Sc., F.C.S., Associate. "The Working Efficiency of Secondary Cells," by Prof. W. E. Ayrton, F.R.S., Vice-President, C. G. Lamb, B.Sc., E. W. Smith, and M. W. Woods, Associates. The Executive Council of the Exhibition have kindly arranged for members excursions to the Forth bridge, and in electric launches up the Union canal. The Great Northern Railway Company will grant to members return tickets, available for eight days, at a single fare and a quarter. I am also in negotiation with the London and North-Western Railway Company for a reduction of fares. The hotel accommodation in Edinburgh is very ample, and the tariffs are about the same as in London. As the final programme depends to a great extent on the numbers who will be present at the meeting, it will be necessary, if it is your intention to attend, that you should advise me on or before the 30th inst., when any further details shall be communicated to you as early as possible.

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Iron-Filing Curves.—In our issue of March 21st we described a method, due to M. Korobow, of fixing iron-filing curves by means of melted paraffin. M. Decharme, in *La Lumière Electrique* of June 19, urges as an objection against this method that, like most others, it only fixes the curves when the iron filings are no longer under the influence of the magnetising force, so that a *dead* figure (*spectre mort*), and not a *live* figure (*spectre vif*), is reproduced. The method employed by M. Decharme to obtain a photographic reproduction of the *live* curves, which, as he states, differ considerably for strong magnetic forces from those obtained after the magnet is removed, is as follows:—A sheet of ferro-prussiate paper is stretched evenly over a thin glass plate. A magnet is then placed either under or on the top of the glass, and the paper is sprinkled with filings, and smartly tapped, as usual. After the curves have been formed the whole arrangement is immediately exposed to the light, and a photographic reproduction is thus obtained of the *live* curves.

The Marvin Electric Drill.—The Marvin electric percussion drill, says the *Electrical World*, consists of an iron bar, to which a drill is connected, reciprocating axially between two solenoids intermittently energised by pulsations of current delivered to the two coils in alternation over separate circuits, from a special dynamo. The two solenoids are mounted in a boiler tube casing, and the whole apparatus is mounted upon an adjustable support. As the coils are alternately supplied with pulsations of current over separate circuits from a special dynamo, no commutating devices or sliding contacts are required either upon the drill or in its vicinity. The moving parts are simply an iron rod travelling axially, and a ratchet arrangement that serves to turn the drill slightly at each stroke. The whole machine is designed to endure the roughest kind of abuse in mines and quarries. The machines now ready are capable of drilling holes from 1ft. to 8ft. deep and from 1in. to 2in. in diameter. They will cut about 8ft. per hour in granite, and require about 5 horse-power. The drill travels in synchronism with the dynamo, and by feeding the machine up to the rock the stroke may be made as short as is desired for starting a hole, while the number of strokes per minute remains the same. A peculiar property of the machine is that when the machine is withdrawn out of striking range of the rock the plunger immediately loses its stroke. It takes up a position about midway between the coils, and its motion becomes a mere quivering. There is no pounding against buffers, as the rod is perfectly cushioned by the magnetic action of the coils. At full stroke the drill has an excursion of about 4in., and strikes 650 blows per minute. It is of about the same weight and bulk as an air drill of the same capacity.

The Transfer of Provisional Orders.—In answer to a question by Mr. O. V. Morgan last week, Sir M. Hicks-Beach said that he was not aware that Local Authorities had any power to transfer gas or water undertakings acquired by Provisional Order or Act of Parliament without statutory authority; but provisions had been inserted in the Electric Lighting Orders, granted this Session, authorising Local Authorities to transfer their powers and liabilities to any Company or person with the consent of and upon terms to be approved by the Board of Trade. He was advised that such provisions were not *ultra vires*.—On Wednesday evening last Mr. Morgan asked the President of the Board of Trade whether the effect of the provisions which the Board had inserted in Electric Lighting Orders now before Parliament, authorising Local Authorities to transfer their undertakings, would be practically to confer upon the Board of Trade powers to perform functions heretofore exercised by Parliament, and also deprive the public of the means that they now had of resisting any such transfer by appearing before a Parliamentary Committee where evidence was taken upon oath; and whether the Board would have the power to administer an oath if the functions of Parliament were so vested in that department? Sir M. Hicks-Beach said that Section 11 of the Electric Lighting Act, 1882, provides that "no local authority, company, or person shall by any contract or assignment transfer to any other company or person or divest themselves of any legal powers given to them, or any legal liabilities imposed on them by this Act, or by any licence, order, or special Act, without the consent of the Board of Trade." The Provisional Orders granted under the Act referred to require that public notice of the proposed transfer shall be given, and the transfer cannot be made without the consent of the Board of Trade, by whom the deed of transfer must be approved, and who will make any inquiries that they may consider necessary in the interests of the public. The Board of Trade would have no power to administer an oath. With regard to the merits of the clause, he wished to point out that the Local Authorities, who are representatives of the rate-payers, ought to be the best judges of their interests in matters affecting the lighting of the town.

Water Power Installations for Electric Lighting.—In connection with the Paper on this subject, recently read before the Institution of Civil Engineers, the following particulars of Lord Armstrong's hydraulic plant at Cragside, supplied by Mr. Bernard Drake, may be of interest:—The first plant consists of a turbine, having a fall of 385ft., the water being conveyed in a 7in. pipe through a distance of 1,200 yards, the speed of the turbine being 1,300 revolutions. The horse-power obtained is 27, which is utilised for driving two dynamos coupled tandem on the same axis. The distance from the house is about a quarter of a mile, and the current is conveyed partly overhead and partly by bare copper conductors laid in wooden troughing, and carried by flat pottery supports. One of the dynamos is compound-wound, and is used for the direct supply of lamps in the building. As switching off of a portion of the lights would cause the remainder to be overworked, unless the turbine were checked instantly, an electrical system has been worked out to control the turbine automatically. This is effected as follows: The main ring contact-switch placed in the house carries a small separate switch, so arranged that before the main circuit is altered a current is passed through one or other of a pair of magnets fixed near the turbine. These magnets give a pull of 30lb., which is used to open or close a cock leading to the main piston, which opens or shuts the blades of the turbine. An electrical system of starting and stopping worked from the house has also been worked out by Messrs. Drake and Gorham. The second dynamo is used for charging accumulators. The second plant is used for the electrical transmission of power. The fall is 29ft., and the horse-power 10. The generator is driven by a belt, and the current is conveyed to the workshops, a distance of 750 yards, by bare overhead conductors. A continuation of this circuit has been made a further distance of 750 yards to the house, by means of which the current can be utilised for electric lighting in case of emergency. The electric motor drives a large circular saw, and a number of other tools. The motor is compound-wound in a special manner, which enables the work to be removed suddenly without any danger. The third plant is used for ploughing and other farm purposes, such as raising weights for ensilage, &c. This turbine gives 30 horse-power, with a fall of 190ft. The water is conveyed a distance of 400 yards through an almost horizontal pipe of 18in. diameter, and afterwards through 300 yards of 10in. pipe. The type of turbine is that of Prof. James Thomson, made by Gilks and Company, in which the water is taken in at the circumference and discharged at the centre, the speed being controlled by the alteration of the angle of the guide blades. Another of these turbines has recently been fitted by Messrs. Drake and Gorham, in connection with the lighting of Alnwick Castle, where the fall is very low and the horse-power over 30.—Another station, similar to that at Keswick, was erected at Okehampton in December, 1888, by Mr. W. Geen, and has been running successfully without any breakdown up to the present time. A Leffel turbine with 15ft. fall is used. The larger portion of the mains are laid under ground in glazed stoneware socket pipes. Early in 1889, Mr. Geen commenced operations at Lynmouth and Lynton, where alternate-current transformers are used. Two Mordey alternators are being run at present, each having an output of 600 16 candle-power. These are driven by a turbine of the Little Giant type, of special construction to suit the fall, which is 95ft., and giving off 200 horse-power. The turbine is horizontal, with the shaft projecting at each end, and the alternators are fixed in line with the turbine shaft with a suitable coupling at each end, so as to use one or both alternators as may be required.

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MAGNETISM IN IRON AND OTHER METALS.*—XXI.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 169.*)

§ 84. **Effects of Vibration.**—The influence of vibration and mechanical disturbance generally upon magnetic quality has been shortly referred to in § 64; it may be succinctly described by saying that vibration lessens those differences of magnetic condition to which hysteresis gives rise. Thus, if we tap a piece of iron during the application and removal of magnetising force, we find at each stage of the application that tapping increases the susceptibility, and at each stage of the removal it reduces the retentiveness. Whatever be the exact nature of the molecular rearrangement which constitutes magnetisation it is facilitated by vibration, which may be imagined to act by setting the molecules momentarily free, more or less, from the constraint in which they ordinarily lie. An analogy may be drawn to the way in which iron turnings scattered on a table near a magnet are freed to range themselves along the lines of magnetic force when the table is tapped; but it must not be inferred that the constraint of the magnetic molecules has anything of the quality of mechanical friction. What that constraint probably is will be discussed in a later chapter.

In strong fields the influence of vibration is scarcely felt; in weak fields it is often enormous. The effect in a weak field is well shown by the familiar experiment—described by Gilbert nearly three hundred years ago—of magnetising a bar of iron by hammering it while it is exposed to the earth's magnetic force. Let the bar, for instance, be held upright: the vertical component of the terrestrial field is too weak to produce more than the feeblest trace of magnetism so long as there is no mechanical disturbance. When sharply tapped, however, it becomes a fairly strong magnet, and the magnetism taken up in this way will persist after the bar has been withdrawn from the field until it is expelled by further tapping or by the application of a moderately strong magnetic force of the opposite sign. The magnetism acquired by an iron ship in building is another instance in point, and still another is the magnetism which the shock of rupture produces in a specimen of iron or steel broken in a testing machine. Vibration affects all the magnetic metals more or less, but it is in soft annealed iron wire that its influence is most remarkable. Gentle rubbing will give much magnetism to a soft iron wire suspended in the terrestrial field, or will take away much of the large residue which persists after a strong magnetising force has ceased to act. Much care is, in fact, necessary in experiments on the susceptibility or retentiveness of this material to avoid serious errors through accidental disturbance of the specimen. The effects of hysteresis almost entirely vanish in the magnetisation of soft iron wire, if the piece be briskly tapped during application and removal of the magnetising force. The curves of **I** and **H** or **B** and **H** in the two processes become nearly coincident, and the relation of magnetism to magnetising force becomes comparatively determinate. Two experiments may be quoted to show these effects.†

§ 85. **Experiments on the Effects of Vibration in the Magnetisation of Soft Iron Wire.**—The wire was a piece of very soft annealed iron, 0·158cm. in diameter, and 64cms., or 400 diameters long, of the same quality as that tested in the experiments of § 64. The test was made by the ballistic method; the magnetising force was raised by steps, and after each step the wire was vigorously beaten against the table, and the magnetism was then measured by slipping off a movable induction coil. Observations were made in the same way at a series of stages during the removal of the force. Table VII. gives the values of **B** found after tapping, first, during application, and then during removal of the force, when the magnetising force due to the solenoid had the values stated in the first column.

A glance at the figures will show the enormous increase of susceptibility brought about by tapping. A force of 0·96 in the solenoid, with tapping, brings **B** up to 9,540; but another

TABLE VII.—*Magnetisation of Soft Iron Wire with Vibration.*

Magnetising Force due to Solenoid.	B During Application.	B During Removal.
0	240 (initial)	400
0·04	840	1,440
0·15	3,370	—
0·31	5,370 ↓	5,850 ↑
0·62	8,260 ↓	8,500 ↑
0 96	9,540	9,860
1·60	10,740	11,200
2·92	12,040	12,400
5·04	13,140	13,000
7·00	13,460	13,550
16·8	14,750 →	

experiment on the same piece of wire showed that without tapping the value of **B** under the same force was only 550. In Fig. 54 curves are drawn, with a very open scale of **H**, to illustrate the portions of this experiment which deal with feeble magnetic forces. The full line, O P, refers to the application of magnetic force; the dotted line above it refers to the removal of the force, both with tapping, while the line O Q refers to the application of magnetic force without tapping. The magnetic force plotted here is that due to the solenoid alone, but it is important to notice that this is by no means the true total force in the experiment made with vibration. Though the wire is 400 diameters long, it cannot be treated as sensibly endless. The reaction of the ends becomes very important on account of the excessively great susceptibility. The real field is much less than the field due to the solenoid—how much less may be judged from the line O A, which is drawn (in the manner

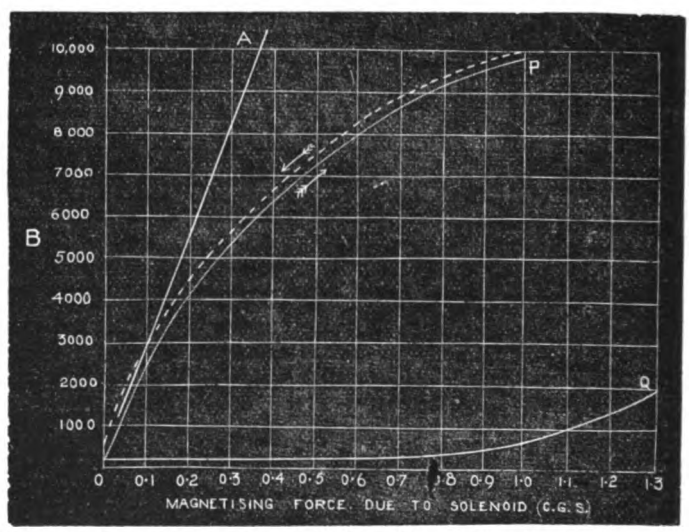

FIG. 54.—Magnetisation of soft Iron Wire; O P, with vibration, O Q, without vibration.

described in § 48) on the supposition that the wire may fairly be treated as an ellipsoid 400 times as long as it is broad. Even neglecting this correction of the magnetic force the ratio of **B** to the (solenoid's) force is not less than 20,000 in the initial part of the curve; and after allowing for the influence of the ends of the specimen the permeability is found to have the enormous value of about 80,000. The permeability is greatest at or near the beginning; the concavity, which is a feature in the early part of curves determined without tapping, has nearly, if not quite, disappeared.

The complete experiment is shown in Fig. 55. The curves shown by full lines were obtained by applying and removing a magnetising force of nearly 17 units without vibration. The curves shown thus — - - - - - refer to the same process performed with vibration. Finally, after magnetising again to the point *a with* vibration, the application of magnetic force was continued *without* vibration, and the results of this are shown by the dotted curve . . . . It is interesting to notice how the hysteresis immediately re-asserts itself when, after tapping, we continue the magnetising process with the specimen at rest.

* All rights are reserved. † *Phil. Trans.* Roy. Soc. 1885, p. 564.

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In another experiment, with the same piece of wire, the magnetic force was raised to a certain value, without vibration, while B was determined ballistically; then the wire was smartly tapped, and the change which B underwent through the tapping was measured by slipping off the induction coil; then the coil was replaced, and the force was raised by steps to a higher value; then the wire was again tapped, and so on. The wire had an initial magnetism (B) of 170, which rose to 190 when a force of 0·32 was applied without tapping; then while this force continued to act tapping brought up the value of B at a bound to 6,620. Again, under a force of 1·61 tapping changed B from 7,120 to 11,600, and under a force of 3·4 it changed B from 11,940 to 12,960. Coming down the effects were equally well marked.

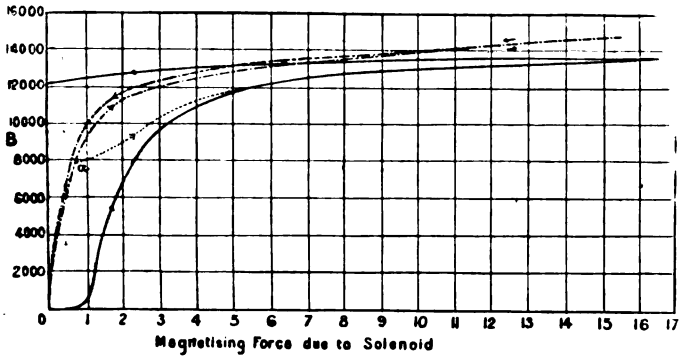

FIG. 55.—Magnetisation of very soft annealed Iron Wire. Without tapping, ———; with tapping, - — - — - — -; continuation, without tapping, after reaching (with tapping) the point *a*, ...

When the force had been reduced from a fairly high value to 0·33, tapping brought B down from 11,260 to 6,880, and finally when the force was 0 the residual value of B, amounting to 6,880, was reduced by tapping to 320. The forces stated here are those due to the solenoid without allowing for the reaction of the specimen itself upon the magnetising field. The complete results of this experiment are shown in Fig. 56, where the full lines show those parts of the process which were performed without tapping; and the changes of magnetic state brought about by tapping, while the external field was kept constant, are shown thus: ——-——-.

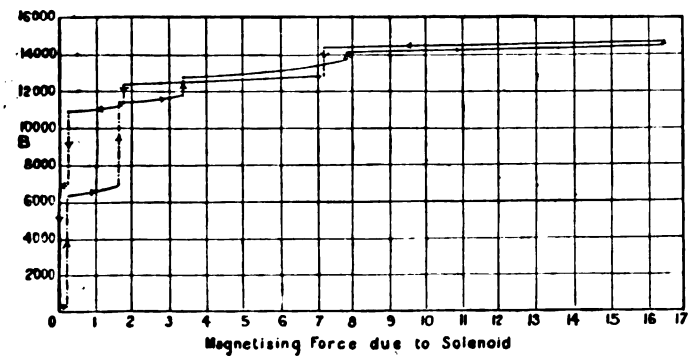

FIG. 56.—Magnetisation of very soft annealed Iron Wire. Effects of tapping shown thus, - — - — - — -.

In experiments of the same kind with hard iron or with steel vibration produces effects of the same general kind; but its influence in destroying hysteresis is far less complete than in soft iron. In a piece of iron wire of the same quality as the last, but not annealed, where a residual magnetism (B) amounting to 7,000 was left after applying a force of 17, the residue fell to 2,500 when the specimen was smartly tapped.

§ 86. Permeability with respect to Small Magnetic Forces.—The instances which have been quoted may suffice to give a general notion of the behaviour of iron and the other magnetic metals when exposed to magnetic fields of moderate strength. It remains to give some account of experiments dealing with the two extremes of weak and strong magnetisation. The effects of weak fields will be taken up first.

A glance at the curves of B and H or of I and H for any of the examples which have been already given will serve to show that the initial permeability—that is to say, the permeability at the beginning of the process of magnetisation—is so small that special means are required to examine its value. The arrangements for measuring this early magnetism, whether they are ballistic or magnetometric, must be much more sensitive than in experiments which deal with later portions of the curve. So small, indeed, is the permeability under very feeble forces, compared with the permeability found later, that without special appliances one might readily fall into the error of supposing it to be initially zero. Experiments made by Baur, Lord Rayleigh, and others are conclusive, however, in showing that this is not the case. They show that the initial permeability has a finite value which is applicable, without sensible change, so long as the magnetising force remains very small. In other words, the magnetisation curve starts with a definite gradient, and its very early portion is nearly straight. Lord Rayleigh has carried his investigation of the action of weak forces further, showing that the permeability has a finite value with respect to any small cyclic change of magnetic force when that is frequently repeated—a value which is sensibly constant when the range of change is varied, provided the range be kept very small, and which is approximately independent of the mean condition as to force and magnetisation, provided the magnetic state does not approach saturation.

Baur's experiments were made ballistically with a ring of soft iron, the cross-section of which had a diameter of a little over two centimetres. Reduced to C.-G.-S. measure, his results for one trial are as follows:—*

H	I	κ
0·0158	0·263	16·5
0·0308	0·547	17·6
0·0708	1·633	23·0
0·1319	3·815	28·9
0·230	9·156	39·8
0·384	22·487	58·6

When these values of susceptibility κ are plotted in relation to H, they are seen to lie on what is practically a straight line. By producing the straight line backwards, the value of κ corresponding to $H = 0$ is found to be 14·5. This is, therefore, the susceptibility with respect to indefinitely feeble forces; the corresponding initial permeability, μ, is 182. Moreover, with respect to forces which are still feeble though not indefinitely small, the susceptibility and permeability may be expressed by the equations

$$\kappa = 14{\cdot}5 + 110\ H\ \dagger$$
$$\mu = 183 + 1382\ H,$$

which apply with much accuracy within the limits of H used in the experiments. With considerably higher force, however, these formulas would not apply. It follows that the relation of magnetisation to magnetic force for feeble forces may be expressed thus:

$$I = 14{\cdot}5\ H + 110\ H^2$$
$$\text{and } B = 183\ H + 1382\ H^2.$$

These particular numerical constants are, of course, to be taken as applying to the specimen of soft iron tested by Baur; but similar parabolic formulas may be constructed with different constants for any specimen of any of the magnetic metals. In other words, the curve of I and H or of B and H is sensibly a parabola in its earliest stages, starting, however, with a finite inclination to the axis of H. For excessively feeble forces it is virtually an inclined straight line, the term involving H^2 being then negligible.

* C. Baur, Inaugural Dissertation, Zurich, 1879. Wied. *Annalen*, XI., 1880, p. 399.

† Baur gives $\kappa = 15 + 100\ H$, but the constants given above seem to the writer to agree better with the numerical results of the tests.

(To be continued.)

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IMPROVEMENTS IN CABLE SHIP GEAR.

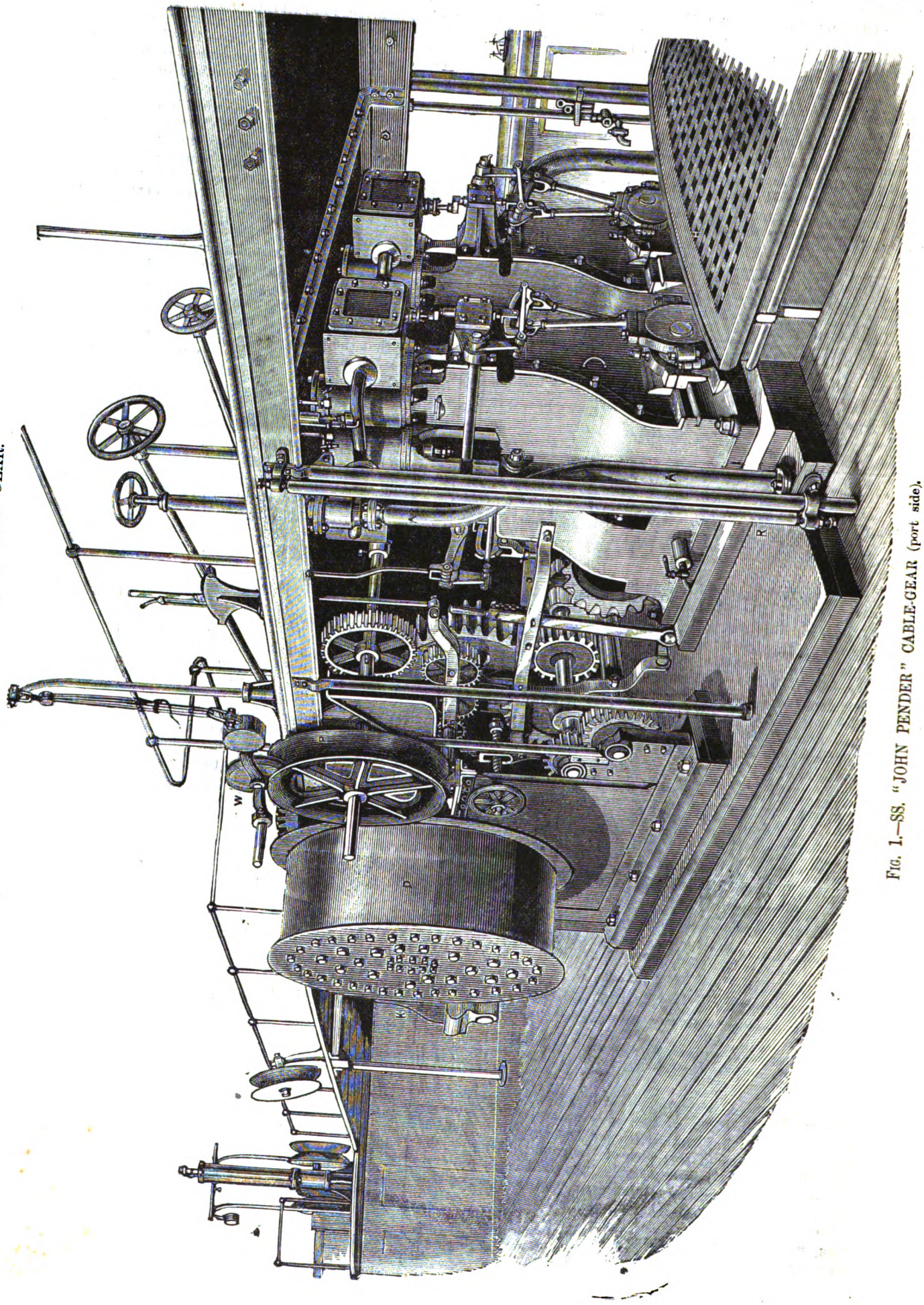

FIG. 1.—SS. "JOHN PENDER" CABLE-GEAR (port side).

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IMPROVEMENTS IN CABLE SHIP GEAR.

BY H. D. WILKINSON, M.I.E.E.

In the operations connected with submarine cable repairs it has been found of considerable convenience and advantage to have independent control over the picking-up and paying-out gear on board ship when these two operations are carried on simultaneously over the bows.

During repairs, except for very long lengths, it is now the usual practice to pay out over the bows, and when the fault has been removed and the ship has payed out up to the buoyed end to make the final splice, the double operation has to be performed of picking up the rope by which the cable has been moored, and paying out on the repaired end. In ships provided with only one drum forward, it is customary to wind the mooring rope round the drum in the opposite direction to that in which the paying-out cable is wound, so that the one drum performs both operations. This has the disadvantage that as much slack cable is payed out as the length of the mooring rope, which, in deep water, entails the laying of considerably more slack than necessary. To avoid this loss the payed-out end may be made fast; but this is not satisfactory, as the strain on the cable is always great, and may increase rapidly at any moment as picking-up proceeds. In some ships, such as the steamship "Electra" (Eastern Telegraph Company), there are two drums, either of which can be thrown in or out of gear. With this arrangement the drum used in paying-out is coupled to the train of gear driven by the engine until arrival at the buoy, when it is held and controlled by a powerful brake, and thrown out of gear with the engine. The latter then drives the other drum, and hauls in the mooring rope. As the strain increases, the brake is partially released, allowing the drum on the paying-out side to slip and pay out slack to relieve the strain. By this means there is no unnecessary slack payed out. An improvement on this is to provide two independent trains of gear, each with its own drum and driving engine. This has been done in the cable ships "Amber" and "John Pender" of the Eastern Telegraph Company, the engines being horizontal, and the gear designed and fitted by Messrs. Clark, Muirhead and Co., in the case of the steamship "Amber," and the engines vertical, and gear designed and fitted by Messrs. Johnson and Phillips in the steamship "John Pender." It is of the gear recently fitted on board the "John Pender" that this article is descriptive.

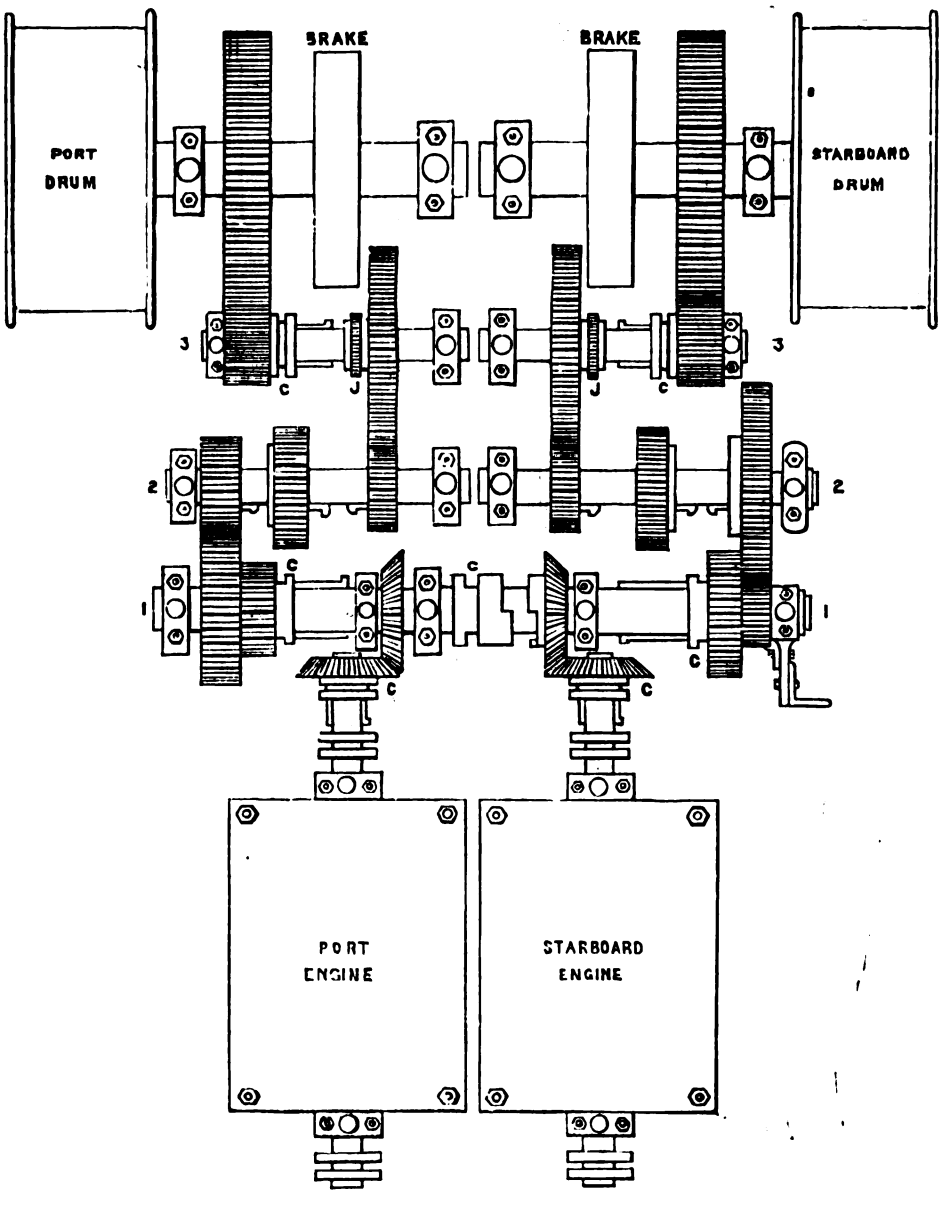

FIG. 2.—Plan of gear

By reference to the perspective view of the gear (Fig. 1) it will be seen that the starting valves of the two engines and their reversing gear are operated from the bridge. From this platform also the brakes on the respective drum shafts are controlled and the jockey pulley thrown in or out of gear. The other changes in the gear are made below the bridge as required. In this view it will be noticed that the hatch opening on the main cable tank is situated close to the gear at H, the ship

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having two more tanks forward and one more aft. During paying-out, the cable is drawn up from the tank by the jockey wheel and pulley shown at W and P respectively; the traction or hauling power on the cable being regulated by the weight on the lever carrying the jockey wheel. The cable passes through an iron eye in the centre of the hatchway above the tank, round the outside of the vertical roller R, over the jockey pulley P, and three times round the drum D. Thence it is led forward over a guide pulley, under the dynamometer pulley, over a second guide pulley, and over the bow sheaves. When paying out from the aft tank guide pulleys are laid at intervals along the deck to guide it to the jockey and drum. The spindle carrying the jockey pulley carries also a brake wheel, the friction on which is maintained by a lever and weight.

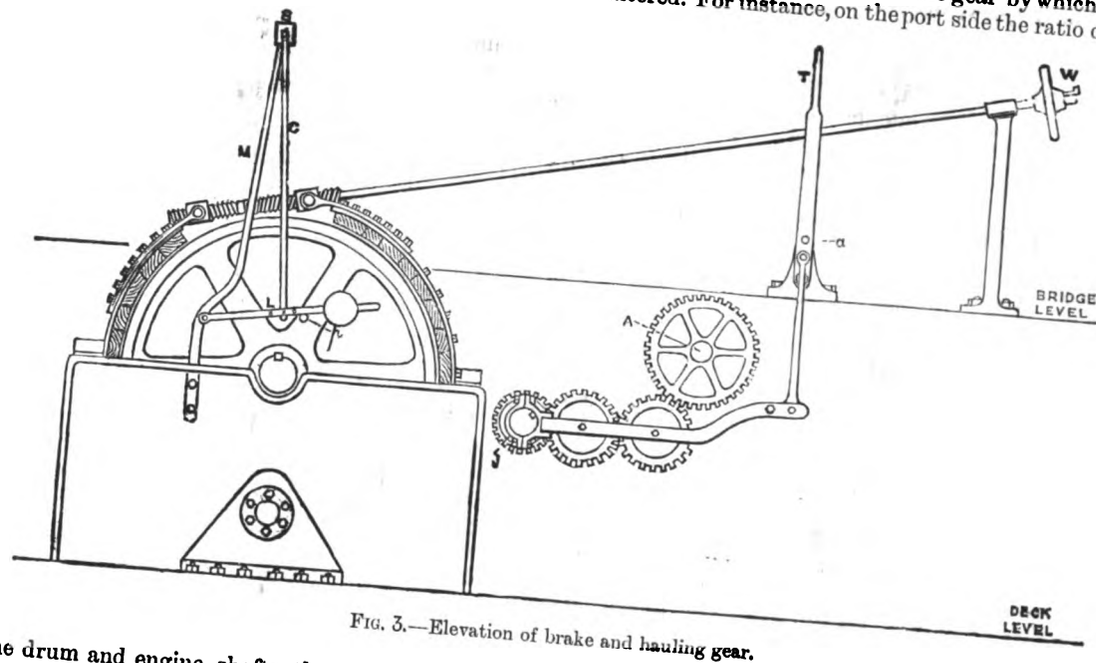

FIG. 3.—Elevation of brake and hauling gear.

Between the drum and engine shafts there are three intermediate shafts for reducing the speed. These run athwartships parallel to the drum shafts, and are numbered 1, 2, and 3 on the plan (Fig. 2) for reference. The engine shafts are fore and aft, and drive by bevel gear on to the first shafts in the train

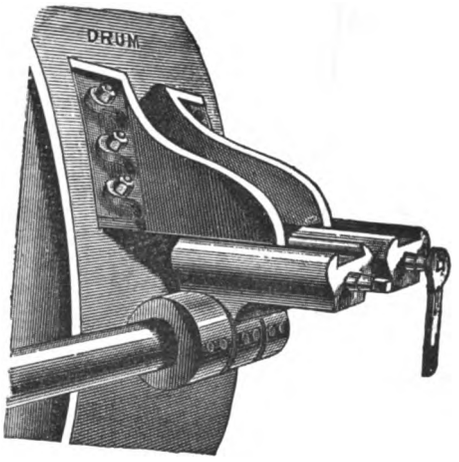

FIG. 4.— Drum knives.

of gear, but can be uncoupled when required by shifting the bevel on the engine shaft. The port and starboard No. 1 shafts can be coupled together by the central coupling C if required; thus both trains of gear can be run by one of the engines, and this can be made to operate either or both drums. For this purpose the cog wheel driving that on the drum shaft can be shifted along a feather on No. 3 shaft, so as to disconnect the corresponding drum from the gear. On No. 3 shaft is keyed a small spur wheel J, operating the jockey pulley spindle. This gear is best seen in Fig. 3, in which the spindle is at A, and has keyed to it a spur wheel, as shown. When the lever T is vertical, this wheel is thrown into gear with the shaft at J. To uncouple the pulley from the gear, the pin at *a* is removed and the lever T let down. This is required when paying-out with the brake on the drum only; the pulley is then free from the train of gear, and revolves by the friction or weight of the cable passing over it. The object of this pulley being to guide the cable to the drum, the shaft on which it is mounted projects by the width of the drum, and the pulley (which slides on a feather) can be made fast by a set screw in any required position.

Between the first and second shafts of the transmission (*see* plan) there is a single and double gear by which the speed may be altered. For instance, on the port side the ratio of the speeds of the drum and engine shafts may be either as 6 : 100, or as 3 : 100, according to which gear is used. The type of brake used is shown in Fig. 3, where W is the hand wheel on the bridge, by which one of the brakes is adjusted. This operates a right

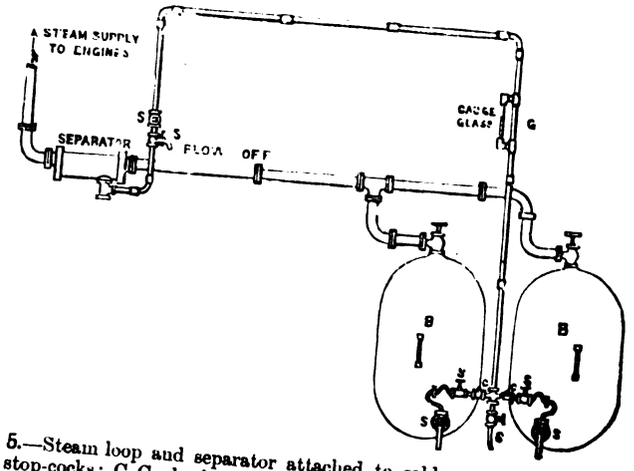

FIG. 5.—Steam loop and separator attached to cable-gear engines. S, S, stop-cocks; C, C, check or non-return valves; B, B, main boilers. (The steam-pipe connections to main engines not shown.)

and left-handed screw, gripping or releasing the brake. In this figure the speed counter gear is shown at S. This is operated by a lever L, fulcrumed on the fixed arm M, which receives an upward movement every revolution by the pin *p* attached to the cog-wheel on this shaft. This movement affects the speed counter through the arm C. The drum has a circumference of 18 feet, and therefore 30 fathoms of cable are payed out for every ten revolutions. For keeping the turns of cable in the centre of the drum the knives shown in Fig. 4 and at K in Fig. 1 are provided. These can be adjusted in position with

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respect to the drum face so as to prevent banking up against the cheeks of the drum and overlapping.

The engines are by Messrs. Robey and Co., and, as will be seen in the engraving, are double cylinder verticals. The support to the cylinders in each engine is in two castings, bolted together with front and back plates, forming a hollow framework, in which the crank shaft revolves in oil and water. This framework forms internally the guides for the crossheads, and to it are bolted externally the brackets for valve spindle guides and reversing gear, the links and excentrics for the latter being outside. The vertical space occupied by the engines and gear between the main deck and bridge is about 6ft. 6in., the stroke being 15 inches. Sight-feed lubricators are fitted to each engine. The holding-down bolts are secured underneath the deck, which is of iron, by 8-inch baulks of timber and large plate iron washers.

The steam pipes are shown at A A, being connected together underneath the deck, and running into the steam pipe supplying the forward winch and windlass. Immediately below the deck a steam separator is inserted in the steam pipe, from which a 1½in. drain pipe is led upwards, as shown in Fig. 5. This drain pipe is carried along horizontally at the height of the bridge to the engine-room, where it is dropped and connected to the main boilers through check and stop valves, as shown. This

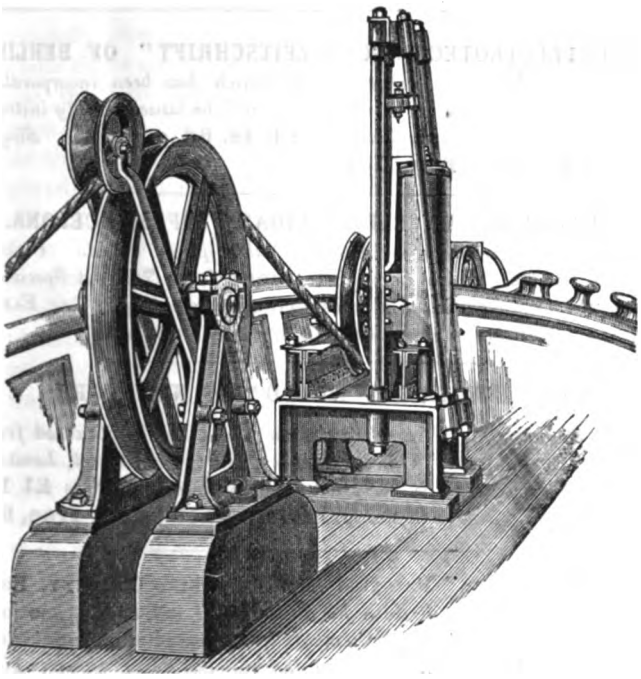

Fig. 6.—Paying-out gear (aft).

returns all water drained from the separator direct to the boilers, the action of the apparatus depending on the increased pressure due to the height of water in the vertical portion of the piping dropped to the boilers. It appears strange at first sight to see a drain pipe from a separator carried upwards instead of downwards, and still more so to see that there is sufficient pressure to return water to the boilers; such is, however, the case, as may be noticed at any time by shutting the stop-cock at the boiler. The accumulated water then rises in the pipe, and may be noticed at the gauge glass G, instantly descending and entering the boiler on re-opening the stop-cock. The system is an American patent worked by the "Steam-Loop and Separator Company," and appears to be of considerable utility in providing dry steam to engines situated at a distance from the boiler. At sea there is the additional advantage of economy in fresh water. The separator is of special construction. Steam passing through it is checked in its course by striking against a set of vertical combs, so arranged that the steam pursues a zigzag course between them. In so doing it delivers its moisture up, which runs down the combs, and through holes into the drain below. The Edison Electric Light Station at Chicago has this system installed with the best results, and it seems not improbable that it may prove of great service to electric light installations, where trouble is experienced from condensation in steam pipes and cylinders.

When cable is paid out aft it is passed up from the tank over a series of guide pulleys on deck, and finally under the dynamometer pulley shown in Fig. 6. In this figure the guide pulley immediately preceding the dynamometer is shown, the cable being maintained in the groove by a small pulley fixed above it. The dynamometer consists of a piston or plunger working in a vertical cylinder containing oil and water. The piston rod extends downwards outside the cylinder, and is bolted to the bracket carrying the pulley spindle. Any strain on the cable, therefore, raises the pulley, bracket, rod and piston, and is indicated by a pointer on a vertical scale (not shown). The cable then passes over the stern sheave into the sea. While paying out in this manner, the brake on the paying out drum forward is regulated from the bridge, as before described, so as to keep the strain indicated on the dynamometer as constant as possible. As the brake is regulated on the bridge platform, it would be an advantage to indicate the strain somewhat nearer the bridge, either actually or by transmission. The new gear described above has a very solid and compact appearance, and has been designed to sustain a strain of 25 tons, acting in a direct line from the drums. This is considerably above what is usually met with in cable work, and the gear is, moreover, capable of bearing double that strain, so that an ample margin is provided for.

ON A BALLISTIC ELECTROMETER.*

The quadrant electrometer can be used ballistically if the usual damping arrangement is removed, and the needle suspended by a conducting wire. The impulse given to the needle by a moment M acting for a very short time is equal to $\int M\,dt$; and as M may be made proportional either to V or V^2, where V is the potential difference between the quadrants, it thus becomes possible to measure $\int V\,dt$ and $\int V^2\,dt$. Thus if the needle is charged to a high constant potential, the magnitude of the first swing is proportional to $\int V\,dt$; and if the quadrants are connected with the two terminals of a resistance R through which a quantity Q of electricity passes in a very short time it is easy to see that whatever the self-induction of the resistance R

$$\int V\,dt = R\,Q$$

This formula has been practically tested with a Mascart electrometer, whose needle was suspended with a platinum wire 0·02mm. in diameter, and charged to a potential of 300 volts. With this instrument a discharge of one microcoulomb through a megohm gave a deflection of 130mm. on a scale two metres off, the period of the needle oscillations being 11·6 seconds. It is necessary that the capacity of the condenser used for the discharge should not be too high, or the time taken for the discharge will prevent the electrometer acting ballistically. The action is, however, satisfactory if the product of the capacity in microfarads and the resistance in megohms does not exceed ⅟₁₀th.

In this way large resistances may be conveniently measured, and, as very small quantities of electricity are used, the method is especially suitable for liquid resistances, where difficulties usually arise from polarisation. If, instead of Q being known, R is known, the method is one for measuring electrical quantity; and the electrometer thus does the duty of a ballistic galvanometer. The sensibility may, however, be made very great by giving a high value to R. By a suitable modification of the method, condensers of widely different capacities may be compared, and by connecting the needle to one pair of quadrants the electrometer may be used as a ballistic electro-dynamometer.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, June 27th.

SOCIETY OF ARTS.

9 p.m. Conversazione at Natural History Museum, South Kensington.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

* Abstract of a Paper by M. Gouy, *Comptes Rendus*, June 2, 1890.

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The Electrician.

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PROSPECTS OF ELECTRIC TRACTION.

The recent transformation of two comparatively small concerns connected with electric traction into a single large company with a somewhat inflated capital, and the announcement that a still larger call is about to be made on the public in order to develope the Thomson-Houston and Series systems in Great Britain, lead to the hope that something comparable to the rapid progress of electric traction in the United States may be shortly witnessed in this country. Perhaps the most satisfactory feature of the last-mentioned project is the statement that contracts have already been entered into to the extent of about three-quarters of a million for equipping tramways in various parts of the country. From this we are led to expect immediate solid work, and not months or years of preliminary experimenting, which a visit to the United States by a competent engineer should now render quite unnecessary. When our English inertia—which, as Prof. AYRTON neatly puts it, may be defined as resistance to motion as distinguished from

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resistance to stopping which characterises the inertia of our transatlantic cousins—has been once overcome, we have but little doubt that the electric tramcar will become as familiar an object in our streets as the ubiquitous omnibus; and although the preference will be largely for accumulator conduit or sectional conductor systems, yet, if the English prejudice can anyhow be removed, we should not be surprised to see a very respectable mileage on the overhead system.

If, however, electric traction is to exhibit that rapid and, above all, that healthy development which we all hope it will do, there must be no repetition of the tactics which brought so much discredit and disaster upon electric lighting in the early days of its introduction into this country, and which made the term "pioneering electric lighting" synonymous with everything that should not be. The evils of over-capitalisation, and of paying huge sums for patents of doubtful validity and but small practical utility, have already been ably dealt with in the columns of a contemporary. But there is another point of scarcely less importance upon which much and painful experience was gained some six or seven years ago. Electric lighting, when it first attempted to establish itself upon a commercial basis in this country, had to fight a rival illuminant which was admittedly much cheaper, and was in those days undoubtedly steadier and more reliable if not quite so brilliant. Under those circumstances it was perhaps too much to expect that the first electric lighting contracts should have been taken only at remunerative prices. Even at the present time the cheapness of gas is a standing temptation to contractors to undertake lighting, and especially street lighting, at prices which, if the work were carried out on an adequate scale with an ample reserve of engine power, would leave but the barest margin of profit.

Whatever good this system of taking on contracts at unremunerative prices may have done to electric lighting, has been outweighted, we feel sure, by the harm it has wrought in other ways; and the same considerations apply also to electric traction. If the figures brought forward from across the Atlantic are to be trusted—and we see no reason to question their general accuracy—electric traction, without taking into consideration its indirect advantages, is undoubtedly cheaper than horse or cable traction. In England, no doubt, several of the factors which go to make up the total cost of electric traction per car mile run would have to be modified; but the comparative cost of electric and horse traction will not, we think, be found to be perceptibly affected. There should therefore, in the case of electric traction, be no repetition of the mistaken policy of offering to do work at a price which does not pay, in the hope that, once in possession of the business, past losses may be recouped by enhanced prices. Although the lengthy correspondence which recently appeared in our columns, on the disputed point whether 4½d. per car mile was or was not a paying price for accumulator traction, left the question very much where it was, the conclusion generally arrived at was that even on a large scale the margin of profit would not be very satisfactory. British taste, there is reason to fear, will not permit of the stringing of wires like clothes lines along the streets, and drawing off the current by means of contrivances resembling fishing rods fastened to the roof of the cars. That may be and probably is the case; but until either a really workable underground system is in the field, or British taste has been educated up to the overhead system, we fail to see what permanent good can accrue to electric traction by working accumulator or any other kind of cars at unremunerative rates.

Another feature of early electric lighting, one indeed which has not been quite got rid of—if we may judge by some rose-coloured estimates of a leading London firm of contractors recently laid before a Local Board—is the dazzling of Local Authorities and others with unrealisable visions of huge profits. This device is also one which we trust it will not be found necessary to make use of in pushing electric traction. Electricity as a motive power has a large field in England, larger indeed than many suspect; and since, if properly worked, electric traction is less costly than its rivals, it behoves those who are connected with it to develop it by sound financing and honest estimating.

THE INTERNATIONAL TELEGRAPH CONFERENCE AT PARIS.

At last the Seventh International Telegraph Conference has come to an end. Opening on Friday, May 16th, the Convention was signed on Saturday last, June 21st, having thus lasted thirty-seven days, or two days less than the last Conference at Berlin. The propositions for alteration of rules put forward by various Administrations covered 137 pages of print; but very little has been done which affects the public.

The first thing discussed in the Tariff Commission was a proposition of Germany for a uniform tariff throughout Europe of 2d. per word, which would have involved a heavy loss to all the Companies and most of the Administrations. After an exhaustive debate, the proposition was deferred for consideration at the next Conference, which is to be held at Budapest in 1895. The proposal made by Germany to double the price of code words, that of Austria insisting upon ten words as a minimum in a telegram, and that submitted by Great Britain recommending five words as a minimum, were rejected.

It may be mentioned that the Berne Office has been instructed to prepare a vocabulary containing legitimate words in the eight languages authorised for code correspondence. Three years after the publication of this vocabulary it will be compulsory for the public to choose from it the words they require for code correspondence. This rule will, however, only apply to telegrams sent within the European régime; for messages sent over extra-European lines the Telegraph Administrations concerned have the option of putting the rule into force or not at their discretion. The idea of an authorised vocabulary has long had for its principal supporter Sir James Anderson, the Managing Director of the Eastern Telegraph Company, and it will tend to abolish the constant bickerings over doubtful words which now take place between the public and the Telegraph Administrations. Another advantage is that the operators will get accustomed to the words contained in the authorised vocabulary, so minimising the risk of error in and possibly accelerating the speed of transmission.

As regards reductions of tariff, various reduced rates will come into operation on July 1, 1891, viz., Great Britain to Spain will be 4d. per word, instead of 4½d., and the rate to Portugal and Gibraltar will be reduced from 5½d. to 4½d. per word. Other small reductions will also take place to the Northern countries of Europe, and there will be a reduction of ½d. per word to Greece. The rules and regulations adopted by the Conference are embodied in the "International Telegraph Convention of Paris, 1890," which, until revised by the next Conference, will be the authority as between the Administrations themselves and the Administrations and the public on all questions relating to international messages.

At the final sitting of the Conference, Sir John Pender announced that it was expected that the tariff to Australasia would be reduced from 9s. 4d. to 4s. per word, under a guarantee of revenue from the Australasian Colonies, the negotiations for which were almost complete. It is proposed to bring the reduced tariff into operation on January 1, 1891.

One of the most interesting incidents of the Conference was the presentation, by the Minister of Commerce, Industry, and the Colonies, of the Commandership of the Legion of Honour to M. Nielsen, the Norwegian delegate, who was

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the only delegate at the Paris Conference of 1890 who was present at the Paris Conference of 1865.

As a means of bringing the delegates together socially and so enabling them to soften down the various differences of opinion which arose in the public meetings, the different receptions, dinners, and excursions had a most salutary effect. They may be summarised as follows: A reception and garden-party given at the Elysée by the President and Madame Carnot; a dinner and three receptions given by the Minister of Commerce, Industry, and the Colonies, and Madame Jules Roche; pleasant excursions to the Château of Pierrefonds, with a drive back through the wood to Compiègne; and a day pleasantly spent at Versailles. Also a three-days' trip to Rouen and Havre, with banquets given to the delegates by the Municipality and Chamber of Commerce at each place. The party was conveyed by steamer from Rouen to Havre, thus affording an opportunity of seeing the picturesque scenery of the Lower Seine. M. Jules Roche, the Minister of Commerce, under whose department the posts and telegraphs are placed, also supplied the delegates with tickets for two performances at the Opéra and Opéra Comique. The French Companies gave a dinner at the Eiffel Tower, with an ascent to the top at midnight, where some members of the Conference sung with vigour the national anthems of their respective countries. The breakfast given by the foreign Telegraph Companies at the Hôtel Continental, under the presidency of Sir John Pender, has already been reported at length, and was decidedly one of the most successful entertainments during the whole Conference. Visits were also paid to the sewers and catacombs of Paris.

In closing, a word must be said in praise of M. De Selves, the Director-General of Posts and Telegraphs, who was the President of the Conference, and conducted all the proceedings with urbanity and decision. The State delegates and the representatives of the Companies both presented him with testimonials in the shape of works of art as a souvenir of the meeting. Testimonials were also presented by the Companies to M. Eschbaecher, the secretary of the Conference, and the assistant-secretaries, MM. Gramaccini, Morel, Forestier, Frouin, Bordelongue, and André.

THE ELECTRIC LIGHTING OF BATH.

The inauguration of the public lighting of Bath took place on Tuesday, the 24th inst. The Mayor switched on the lights at 9 p.m., in the presence of a distinguished company of Bath residents and representatives of the Press, after which a supper was given by Mr. Massingham at the Grand Pump Room Hotel to celebrate the occasion. In the speeches which followed the supper, Mr. Massingham's name was duly eulogised for the indomitable energy and persistence which have resulted in the establishment of an electric supply in Bath. How little of the credit of having established the station is due to Bath, and how much to Mr. Massingham, is best seen by the fact that the efforts to form a local company failed, although powers to commence a supply had been secured. Mr. Massingham then boldly determined to put down the works at his own expense.

In the first instance it was proposed to erect the station on a site having water-power; but the power available having been found to be insufficient, the present situation was decided upon in preference. We are informed, however, that it is still intended to secure the former site, and to utilise the water-power for the day supply and hours of light loads. The site selected adjoins the Great Western Railway Station, and has a frontage in Dorchester-street; on the other sides it is bounded by the Avon and a carrier company's premises. Being also close to the main thoroughfares it is on every count an excellent position for an electric supply station.

The original premises—formerly used as a flour mill—constitute the offices and caretaker's house, and light and airy buildings have been erected over the yard abutting on the river for the boilers and machinery. The boiler-house is 40ft. by 90ft., and capable of extension to a length of 120ft.; the engine and electric machinery house is 40ft. by 113ft., and can be extended to 150ft. When these limits are reached, the buildings will accommodate plant for a supply of 300 arc lamps and 30,000 10 candle-power incandescents.

The plant units adopted are:—Babcock and Wilcox boilers of 150 horse-power, working at 150lbs. per square in. pressure; 75 kilowatt Mordey alternators, rope-driven by Raworth vertical compound engines, constructed by the Brush Electrical Engineering Company; and 50-light Thomson-Houston 6·8 ampere arc dynamos, belt-driven by Raworth vertical compound engines. The Thomson-Houston plant has been supplied by Messrs. Laing, Wharton and Down. No counter-shafting is employed, the engines and dynamos being equal in number, and each engine constructed to be economically loaded by its own dynamo when connected to the supply mains. The condensing arrangements are not yet in operation, owing to a defect in the circulating pump; but the plant already put down, consisting of one surface condenser and circulating and air pumps, are stated to be equal to the requirements of the present plant. At present there are two boilers in position, and two sets of engines and 75 kilo-watt alternators, and two more of each of the foregoing are to be delivered by September 1st. The number of arc sets already installed is four.

The boilers are supplied with feed-water by a Dean pump, and injectors have been fitted to each as stand-byes; the latter, however, are found to be practically useless on account of the large amount of deposit from the water, which is continually causing them to fail; and a second pump is consequently being put in as a safeguard. The steam is carried from the boilers by 5in. pipes into a 6in. main, which runs lengthways along the engine-room. The latter is divided into sections by valves at intervals, so that in case of accident a section can be shut off from the boilers, and independent connections are to be made in the boiler-room so as to minimise the amount of plant disabled by any accident to the steam piping.

The engines which drive the alternators are capable of indicating 150 horse-power, and run at 185 revolutions per minute; they are fitted with screw gear, worked by a hand wheel, for varying the cut-off; while what may be called the fine adjustment is made by a Hindley governor operating a throttle valve. We believe that these engines are the first, or nearly the first, which have been constructed by the Brush Electrical Engineering Company of this size. So far they have given complete satisfaction; they have a first-class appearance, and the simplicity of the design, and accessibility of all the working parts to the attendant, should enable him to detect the slightest irregularity at once, and so lessen the chance of an accidental stoppage. Beyond putting down good solid foundations no precautions against vibration have been necessary, owing to the nature of the surrounding property.

The alternators run at 500 revolutions per minute, and give an E.M.F. of 2,000 volts, and a current having a period of 100 $\sim$ per second. Constant circulation of the oil is maintained through the bearings by means of small rotary pumps, driven by light bands from the dynamo shaft. The high-tension mains rise vertically from the dynamos, after which they cross over to the wall and descend to the switches and instruments. Each machine is provided with a switch, which consists of two independent levers, hinged at one end, and fitting in between two copper brushes at the other; a spring at each hinged end causes the levers to fly out from between the brushes, unless secured by a catch. The levers are pulled down by two cords, to which a ring is attached, and the catches snap over their ends. Two other cords are attached to the catches, by pulling which the levers are released and fly out, breaking the circuit. A lad is employed to keep the volts constant, and to register the outgoing current. The volts are indicated by a Cardew voltmeter connected to one coil of the armature, and registers $\frac{1}{24}$th of the total E.M.F. The lad varies the volt by means of a sliding contact, which rubs on the coils of a platinoid resistance connected into the exciting circuit.

The engines which drive the arc machines are of 35 horse-power; and the Thomson-Houston dynamos are fitted with a switch, which, by short-circuiting the armature, enables the lights to be turned on or off without the inconvenience and danger which attaches to making or breaking the high-tension current.

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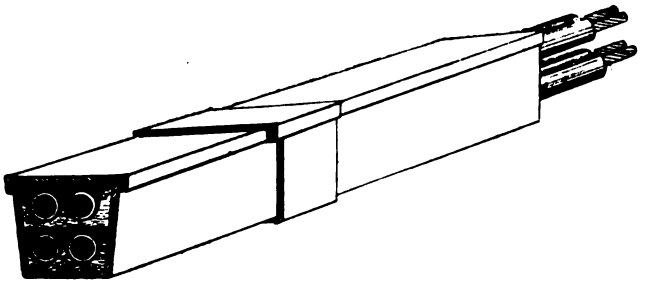
The mains are laid entirely underground on Callender's solid system, which consists in laying the cables in iron troughs, in which they are supported at intervals by wood bridges. When the cables are in position molten bitumen is poured in until the troughs are full, and the whole is covered in by a cast iron lid.

The annexed figure gives a perspective view and section of the main. It is said that there are 30 miles of cables, and that the insulation resistance of the whole when connected up was 30 megohms. There are three independent sets of mains. The first set is for distributing the alternating high-tension current, and consists of eight pairs of feeders, each of 19/16's, which run to the distributing centres. Each pair of feeders has its own distributing network which is not connected to the rest; but cables of sufficient section to carry the whole current run from the distributing centres to points situated between the adjacent networks; so that in case of any accident to a pair of feeders, or repairs being necessary the network fed by them can be coupled up with the adjoining networks and supplied from them in the meantime. Eventually it is intended to connect the alternators in parallel at the station; but the networks will be kept distinct from each other, so as to confine the disturbance which might be caused if an earth or short-circuit occurred—through the pickaxe of a careless but powerful British labourer, for instance—to the locality in which the accident took place. The second set of mains supplies the private consumer's arc lamps, and the third the arc lamps employed in lighting the streets.



The mains have been laid by Callender's Bitumen Telegraph and Waterproof Company (Limited), under the superintendence of Mr. W. Douglas Reid, the Company's resident engineer.

Mordey transformers are employed to provide an E.M.F. of 100 volts on the consumer's premises. We noticed one large installation of about 250 lamps of 20 candle-power, where the lamps are of Woodhouse and Rawson's make; and the report given us was that this firm's lamps were very efficient and durable. The arc lamps (Thomson-Houston) used by private consumers are chiefly employed outside to light the windows of shops, &c. They are in all cases trimmed by the supplier's servants. There are at present 31 arc lamps supplied to private consumers, each of 1,200 candle-power. The street lamps are also of 1,200 candle-power, and are suspended from neat cast-iron posts. The lamps themselves are suspended by a flexible concentric cable, which passes over pulleys fitted into each corner of the bracket arm. The cable passes down the inside of the post to within about 6ft. of the ground, where it terminates in a wedge connector. A counter-balance weight is attached to the cable just above the connector. When the lamp is up in position for burning, the wedge connector is pushed in between two copper brushes connected in the main circuit, by which means the brushes are separated and the current diverted through the lamp. When it is required to lower the lamp for trimming or cleaning, a cord is attached to a hook at the end of the cable, the wedge connector is pulled out, and the lamp descends by an excess of weight over the counter-balance. When the connection is withdrawn, the brushes close together and complete the main circuit. It will thus be seen that the lamps are entirely detached from the high-tension mains except when in position for burning. This arrangement has been worked out by Mr. G. S. Hooker, Mr. Massingham's electrician in charge. The street circuits are two in number, and supply a total of 81 lamps. They are distanced an average of about 90 yards apart; and the general effect about the centre of the town is very good indeed, the Thomson-Houston lamps burning with their accustomed steadiness.

The charge made to private consumers is 6s. per annum for each 10 candle-power lamp wired, the consumer being free to burn his lamps as many hours as he pleases. The necessary check on careless and wasteful burning is provided by the cost of lamp renewals, which the consumer has to meet. Arc lamps are charged for at the rate of £8 per annum if burning from sunset to 8 p.m.; £9 if burning till 9 p.m.; £10 if burning till 10 p.m., and so on. Lamps situated inside of buildings are charged £1 per annum extra. The prices include trimming and cleaning and carbons, but not globes.

The contract with the Corporation, which is of seven years' duration—comes out at about £26 per lamp per annum, and includes trimming and cleaning and finding carbons and globes. The hours of lighting are sunset to sunrise all the year round.

It may be mentioned that the Bristol coal dues raise the price so much that it is found cheaper to get the coal supply by rail. The price now paid is 14s. per ton.

The alternating plant has now been supplying incandescent lights for about three months, and there are about 3,000 lamps wired. It is found that at this time of the year the maximum demand seldom exceeds one quarter of the amount it would reach if all the lamps were turned on at once.

Mr. Massingham must be congratulated on the successful start which has been made, and on the sound and healthy appearance of things both inside and outside of the station.

THE NEW LINEFF SYSTEM OF ELECTRIC TRACTION.

More than two years ago we published a brief description of the Lineff and Jones system of traction. This system, it will be remembered, was of the "conduit" class, the most novel feature being the method of making contact between the car and the underground conductor. A bare copper wire was run inside a gas pipe, into which iron forks were screwed every few feet, their ends clamping down on the copper wire inside, and ensuring a good contact. A flat iron plate at each end of the car ran in the central slot. Between these plates and inside the conduit hung a flexible conductor, consisting of brass "beads," strung on a stranded wire cable. As the car moved along this flexible conductor rested on the forks in the gas pipe never making contact with less than four at once. This system we believe, never got much beyond the experimental stage.

The system now adopted by Mr. Lineff, a demonstration of which was given on Wednesday at the Chiswick High-road Depôt of the West Metropolitan Tramway Company, is on what may be termed the sectional conductor principle. A few inches inside one of the rails are arranged insulated sections of girder iron, 3ft. in length, and embedded in asphalte, the upper flat surface of the iron being level with the roadway. A small channel runs along inside the asphalte under the iron. At the bottom of this channel a flat bare copper conductor rests on china insulating bridge pieces. Upon the top of the copper conductor, and about $\frac{5}{16}$in. beneath the surface conductor, forming the roof of the closed conduit, lies a substantial strip of iron. The car is fitted with a powerful electro-magnet, the cylindrical core of which is somewhat longer than a section of the surface conductor. The pole-pieces of this electro-magnet are spread out considerably, and lie just over the surface conductor, between which there is about $\frac{1}{16}$in. clearance. The magnet is energised by the main current, its coils being in parallel with the motor. As the car moves along the track the magnetic circuit of the magnet on the car is completed through the surface conductor and the iron strip in the channel underneath; the strip is consequently lifted up into contact with the surface conductor, thus completing the electric circuit between the underground main through the motor to the return rails. As only two sections of the surface conductor are "charged" at one time, the "live" sections are always under the car. The current is taken off by means of a small wheel and a brush

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fitted on to each pole-piece of the electro-magnet, the weight of which being some hundredweight, ensures good contact. The car operated on Wednesday was a light open one. It was fitted with a 4-horse power Immisch motor and magnetic brake, the current being supplied at a pressure of 240 volts by an Immisch dynamo.

Mr. Lineff, it will thus be seen, has avoided the use of innumerable electro-magnets for the purpose of bringing the successive sections of his surface conductor into play, and has thereby considerably enhanced the practical value of the closed-conduit system. Whether he has steered clear of previous patents remains to be seen. But, in any case, it is to be hoped that Mr. Lineff's new system will reach a higher stage of development than the one referred to at the beginning of this notice.

THE ELLIOTT SMOKE ANNIHILATOR.

On Wednesday last we paid a visit to Newbury, in response to an invitation to view a Smoke Annihilator which has been devised by Mr. Samuel Elliott, of the Albert Moulding Mills and Joinery Works, Newbury. In this apparatus, the smoke is drawn from the flue by a fan, and by the same means is driven through the machine, or "Annihilator."

The "Annihilator" consists of a square cast-iron tank, in which is mounted a hollow cast-iron cylinder capable of revolution on its axis. One end of the cylinder is closed, and a pivot is provided which fits into a bearing in the end of the tank. The cylinder is continued through the other end of the tank, and supported by a packed bearing or stuffing box. The protruding end of the cylinder carries three pulleys—a driving and a loose one, and one from which the fan is driven. The end of the cylinder is connected to the discharge opening of the fan. Inside the tank the cylinder is drilled with numerous holes about 1in. in diameter, and a number of blades are attached to its periphery extending the whole length of the tank, and of such width as to just clear the sides and bottom of the tank as they revolve. The blades are made of iron sheet, perforated with holes about ⅜in. diameter, the holes being almost as close together as the metal will stand.

When the machine is in operation the tank is filled with water about up to the level of the centre of the cylinder, and the cylinder is revolved at a speed of about 150 revolutions per minute. The smoke is driven into the cylinder by the fan, with a certain amount of steam added—which may be a portion of the exhaust from an engine—and passes out through the holes in the cylinder and encounters the water; it is, in fact, thoroughly mixed up with it by the revolution of the perforated iron blades. The result is that the water becomes of a brownish colour, and a thick black scum accumulates in the top part of the machine, from whence it is drained off into suitable receptacles by sloping channels ending in spouts on each side. A perfectly white vapour issues from the funnel on the top of the machine, which is quite inodorous, and vanishes in the air like steam, which it doubtless is.

The machine shown in operation was connected to a marine boiler of about 100 horse-power capacity; the fires were made to smoke badly, and when a dense black volume was issuing from the chimney the "Annihilator" was put to work, the result being that the black smoke was immediately replaced by perfectly white vapour.

The experiments were not quantitative, so that it was impossible to form a very useful opinion of the commercial value of the invention. That the machine is capable of annihilating smoke there could be no manner of doubt; and if it is found not to absorb too much power when dealing with the large volumes of products of combustion emitted from the flues of a large central station or manufactory, and not to be too costly in itself, there certainly should be a good field for it. On the important point as to how much power has to be expended in the "Annihilator" to deal with a given quantity of smoke, the only information we have is the statement that about 2 horse-power is required to "annihilate" the smoke coming from the furnace of an ordinary 60 horse-power boiler.

We should very much like to see one of Mr. Elliott's machines put into every-day work, say, in connection with one of the London Central Stations, where its capabilities and the cost of operating it could be accurately determined.

The following details of the composition of the dry scum, from a report by Mr. C. W. Heaton, may prove of interest:—

Composition of Dry Scum in 100 parts:—

Organic and volatile matters—		
Carbon	69·45	
Hydrogen	5·04	
Oxygen (different)	7·33	
Nitrogen	1·60	
Sulphur	3·74	
		87·16
Inorganic matters—		
Insoluble matters	2·52	
Soluble silica	1·35	
Ferric oxide	9·10	
	12·97	
Found by weighing		12·84
		100·00

THE MEASUREMENT OF L WITH A CARDEW VOLTMETER.

The following method of measuring L, due to Mr. W. Brew, may prove of some use when the usual reflecting galvanometer, &c., are not at hand. It simply consists in placing the inductive coil or resistance, whose coefficient of self-induction is to be measured in series with a Cardew voltmeter or other instrument of high resistance, whose deflections measure

$$\sqrt{\frac{1}{T}\int_0^T i^2\,\delta t}$$

or the square root of the mean square of the current passing through it; and measuring the apparent resistance of this inductive coil by means of two deflections of the voltmeter (one being obtained with and the other without the inductive coil in series) when in circuit with an alternating potential difference of known periodicity. The apparent resistance, r_1, of the coil is

$$r_1 = \left(\frac{D_2}{D_1} - 1\right) R \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

R being the resistance in ohms of the voltmeter,
D_1 and D_2 being the respective deflections upon it, with and without the coil in series. Also,

$$r_1 = \sqrt{r^2 + \frac{4\pi^2 L^2}{T^2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

r being the resistance in ohms of the coil measured in the ordinary way on a Wheatstone's bridge,
L being the self-induction coefficient required,
T being the time in seconds of a complete alternation,
From (2) we have:—

$$L = \frac{T}{2\pi} \sqrt{(r_1^2 - r^2)} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or, substituting for T the number of alternations per second n,

$$L = \frac{\sqrt{(r_1^2 - r^2)}}{2\pi n} \quad . \quad . \quad . \quad . \quad . \quad (4).$$

The following test of a bobbin 5½in. in length, inside and outside diameter 1in. and 2in. respectively, convolutions about 9,000, and having a resistance of 326ω, may serve to illustrate the method:—

D_1.	D_2.	$\frac{D_2}{D_1}$.	r_1.	n.	$\frac{\sqrt{r_1^2 - r^2}}{2\pi n}$	Remarks.
20·8	65·2	3·134	342·7	58·13	0·435	The resistance of the voltmeter in this experiment was 170ω.
22·0	70·8	3·218	377·0	63·8	0·472	
24·5	77·8	3·176	370·0	58·0	0·480	
18·5	58·2	3·22	377·4	63·8	0·474	

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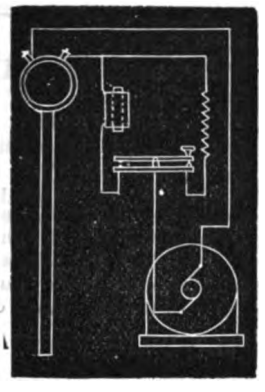
In some cases it may be convenient to employ a non-inductive resistance in series with the voltmeter of resistance equal to the coil to get the ratio $\frac{D_2}{D_1}$ to suit the range of the instrument; this resistance is represented in the sketch by the zig-zag line at the right key; with this arrangement we have in the equation

$$r_1 = \left(\frac{D_2}{D_1} - 1\right) R$$

r_1 equal to $\sqrt{4\pi^2 L^2 n^2}$ alone, and R equal to the resistance of the voltmeter plus the non-inductive resistance. Consequently

$$L = \frac{r_1}{2\pi n} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

which we also get directly from equation (4) by putting $r = o$.



In the above formula, the difference in phase of the potentials on the coil and on the Cardew instrument is neglected. If this is taken into account, a slight change in the formula is necessary. We then have—

$$\frac{D_2}{D_1} = \frac{\sqrt{(R + r)^2 + 4\pi^2 n^2 L^2}}{R} \quad . \quad . \quad . \quad . \quad (6)$$

or

$$L = \frac{R}{2\pi n}\sqrt{\frac{D_2^2}{D_1^2} - \left(\frac{R + r}{R}\right)^2} \quad . \quad . \quad . \quad (7)$$

R being the resistance of the Cardew voltmeter,
r being the resistance of the induction coil.

ON THE HEATING EFFECTS OF ELECTRIC CURRENTS. No. IV.*

BY W. H. PREECE, F.R.S.

The effects of the heat developed in conductors when electric currents are transmitted through them have been the subject of constant investigation on my part since 1878. In 1880 I found that the rapidity with which small bare wires acquired higher temperatures and lost them in air was so great that it was possible to reproduce sound and speech by means of the thermo-telephone (*The Electrician*, June 5, 1880, p. 32; Roy. Soc. *Proc.* No. 204, 1880). I determined subsequently (*The Electrician*, April 12, 1884, p. 518; Roy. Soc. *Proc.*, No. 231, 1884) the current that raised the temperature of small conductors in air to the fusing point, and proved experimentally that, while bare cylindrical wires of very small diameter did not follow the $d^{\frac{3}{2}}$ law, this law became rigid for all diameters above 1mm. Papers (Roy. Soc. *Proc.*, November 24, 1887, and March 15, 1888; *The Electrician*, February 17 and 24, 1888, and April 27, 1888) dealt principally with the fusing points; and the following table, to which I have added silver, gives the fusing constants for all the metals in general use when bare and exposed in still air. The numbers indicate the current in amperes which is required to fuse a cylindrical conductor of a diameter of 1cm. of the material named.

* Read before the Royal Society.

—	Fusing constant (a).	Fusing temperature C°.
Copper	2530	1054
Silver*	1900	954
Aluminium	1875	650
German silver	1292	1200
Platinum	1277	1775
Platinoid	1173	1300
Iron	777·4	1600
Tin	405·5	226
Lead	340·6	335
Alloy (lead 2 parts, tin 1 part)	325·5	180

I have added the temperature of fusion of each of these metals; and the table means that if we take, for example, a uniform copper wire of (d) cm. diameter, the current in amperes needed to raise it to 1,054° C, and therefore to fuse it, is given by the equation

$$C = 2530 d^{\frac{3}{2}}.$$

It seemed natural that these constants, marking such a distinct and well-defined fiducial point, should also enable us to obtain the currents that would raise the wire to any other temperature.

A constant current traversing a cylindrical metallic conductor does work upon that conductor to an amount which is measured per second by the product of the electromotive force (E) at the end of the conductor and the current (C). This work appears as heat. The temperature of the conductor is raised. When the temperature of the wire becomes constant the expenditure of energy in the wire, and its dissipation by radiation and convection from the surface of the wire, must be equal and constant also. Hence the temperature of the conductor when constant becomes a measure of the work done per second, and therefore a measure of the constant current flowing. The rate of loss of heat per degree per unit area of any surface is its emissivity (e). The value of e depends upon the character of the surface, that is, whether it is polished or rough, clean or dirty, bright or black, metallic or oxidised, painted or coated with some preservative or insulating medium. For the present we will consider an unprotected surface comparable with the surface when at white heat, and we will call that surface *normal*. Let a current be applied to a given conductor, exposed in still air at atmospheric pressure, until it assumes any constant temperature, which is (θ) degrees in excess of that of surrounding objects, then the total heat which will be emitted per second by the whole surface (S) of the wire to the surrounding objects will be $eS\theta$, and this must be equal to the heat generated by the current.

Hence $$EC = eS\theta, \text{ or } e = \frac{EC}{S\theta}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Hence we can determine e for any conductor at any temperature by measuring E C and θ.

Putting $E = C R$, $S = l \pi d$, and $R = 4\rho l/\pi d^2$ (ρ being the specific resistance in C.-G.-S. units, l the length, and d the diameter in centimetres), (1) becomes

$$4 C^2 \rho = e \pi^2 d^3 \theta, \text{ and } \theta = \frac{4 C^2 \rho}{e \pi^2 d^3} \quad . \quad . \quad . \quad . \quad (2)$$

Now, if ρ and e vary together in the same proportion in terms of θ, then $\theta = \kappa C^2$ for any particular wire. That ρ and e do vary together in the same proportion is entirely in accordance with measurement and experiment; and it is interesting to note that it is also in accordance with the researches of Mr. J. T. Bottomley on thermo-radiation (*Phil. Trans.*, Vol. 178 (1887), A, pp. 429—450). Thus, if we take the table given on p. 443 of that Paper, and work out the variation in resistance of a platinum wire (which variation is the same as for copper) by the usual formula,

$$R_t = R_0 (1{\cdot}0038)^{\theta},$$

we get the values shown in the fourth column:—

Bottomley's researches.			R_t calculated from the formula $R_t = 14{\cdot}5\ (1{\cdot}0038)^{\theta}$.
θ.	C^2/RJs.	e.	
65°	$9{\cdot}45 \times 10^{-4}$	$14{\cdot}5 \times 10^{-6}$	14·5
110	20·53 „	18·7 „	17·2
232	74·7 „	32·2 „	27·3
383	236 „	61·6 „	48·4
740	1468 „	198 „	187·6
900	3218 „	358 „	344·2

*G. Roux, 'L'Électricien,' December 14, 1889.

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If we determine C for any temperature, then, since $\theta = \kappa C^2$, the current C′ producing any other temperature θ' is obtained by means of the equation

$$C' = C\sqrt{\frac{\theta'}{\theta}}$$

Now, for copper of 1cm. diameter C = 2530 for 1054°. Thus, if we want to find the current that will raise such a conductor to 13°, we have

$$C' = 2530\sqrt{\frac{13}{1054}} = 281 \text{ amperes,}$$

if the surface be equivalent to the assumed normal surface.

Now, since we are dealing with metallic surfaces only, and the normal surface has been defined to be that comparable with the surface when at a white heat, it remains for us to determine the coefficient which shall convert this normal-surface emissivity to that of the surface of ordinary wires at low temperatures. This I have done for copper; and the results have been amply confirmed by Mr. Kennelly, in Mr. Edison's laboratory at Orange, N.J., U.S.A.*

Taking the normal surface as unity, then

	Surface coefficient
Bright and polished copper	0·5
Copper, dirty, oxidised, or blacked with shellac varnish	0·6
Copper, well coated with lampblack	1·0

Taking a wire 1cm. in diameter and calculating from $C' = 0{\cdot}5C\sqrt{\frac{\theta'}{\theta}}$ for bright wire, and $0{\cdot}6C\sqrt{\frac{\theta'}{\theta}}$ for black wire, we get a concordance which is very satisfactory.

5°.				10°.				20°.			
Bright.		Black.		Bright.		Black.		Bright.		Black.	
P	K	P	K	P	K	P	K	P	K	P	K
87	85	104	104	123·2	120	148	147	168	169	201	207

40°.				80°.			
Bright.		Black.		Bright.		Black.	
P	K	P	K	P	K	P	K
243	236	291	290	350	329	420	410

N.B.—P means calculated from the formula $C' = 1265\sqrt{\frac{\theta'}{\theta}}$, and K means the figures obtained by Mr. Kennelly.

Now, the current (C) producing 1054° (θ) in a bare bright copper cylinder of 1cm. diameter is $0{\cdot}5 \times 2530$ amperes, and that which would produce a temperature of 10° C. is

$$0{\cdot}5 \times 2530\sqrt{\frac{10}{1054}} = 123{\cdot}2 \text{ amperes.}$$

Using both alternating and continuous currents, it was found that in a copper wire with $d = 0{\cdot}6956$, θ was 50°·3. Now the current (C) that will raise a wire 1cm. in diameter 50°·3 in temperature is

$$C' = 2530\sqrt{\frac{50{\cdot}3}{1054}} = 552{\cdot}7 \text{ amperes.}$$

But the current that will raise a wire of a diameter of 0·6956cm. through the same temperature is

$$(C \times d^{\frac{3}{2}}) = 552{\cdot}7 \times {\cdot}6956^{\frac{3}{2}} = 320{\cdot}6 \text{ amperes;}$$

or, if the wire be dirty,

$$320{\cdot}6 \times {\cdot}6 = 192{\cdot}4 \text{ amperes.}$$

The current actually was in each case 198 amperes.

A copper conductor, bare and dirty, 20 feet long and 0·415in. in diameter, was stretched across a room where the air was still, and various continuous currents were transmitted through it. The results are tabulated, and the observed and calculated currents given :—

Time.	Increase of temperature of wire C.	Current in amperes. Observed.	Current in amperes. Calculated. $C' = 0{\cdot}6\,C\sqrt{\frac{\theta'}{\theta}}/d^{\frac{3}{2}}$.
10·45		454	
11·15	86°	454	467·7
12·0	80	450	451
3·30	79	445	448
3·45	78	440	445
4·30	73	429	431
Current stopped; wire cooled. Current put on again at 5.30.			
6·0	38	290	310

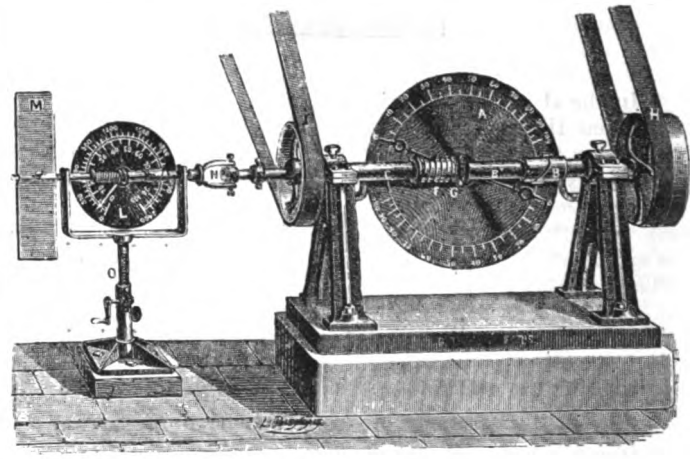
Thus, if we know the current producing any fixed temperature in any cylindrical conductor, we can readily calculate the current required for any other temperature.

* A. E. Kennelly, "On the Heating of Conductors by Electric Currents" (*Electrician*, December 13, 1889), *et seq.*

THE TROUVÉ DYNAMOMETER.*

The following is a brief description of a simple dynamometer designed by M. G. Trouvé, which can be used either as an absorption or transmission instrument.

Power may be considered either as the product of the force exerted and the speed of displacement of the point of application of this force; or, again, as proportional to the product of a couple and an angular velocity. If, therefore, we can measure these two quantities separately, their product will give us the power absorbed or transmitted. M. Trouvé's dynamometer consists of two parts,



The Trouvé Dynamometer

one serving to measure the couple and the other the angular velocity. The measurement of the couple exerted is obtained by means of a flat spring arranged along the axis of the dynamometer, in order to eliminate the effects of centrifugal force. The spindle is hollow at this point, and consists of two concentric tubes. The ends of the flat spring are fixed to these tubes, which are able to follow the rotary and longitudinal movements which the torsion gives to the spring. One of these tubes carries a fixed sleeve B, cut as shown in the annexed figure. The second has a sleeve B′, free to move on it, and which is kept pressed against the fixed sleeve by the spring F, so that when the instrument is at rest B and B′ are pressed one against the other. B′ is provided with a slot, which only allows it to move longitudinally. Under the action of the torque exerted upon the axis of the system the longitudinal motion of this sleeve is utilised to rotate the indicating needle on the dial A, which is empirically graduated. In order to effect this registration the movable sleeve B′ is furnished with a deep groove, G, which engages the extremity of a bent lever connected to the needle.

The dial is graduated empirically in the following manner :—The axis of the dynamometer spring being solidly connected to one end of the shaft of a motor, a double-balanced lever is fixed to the other end. Weights are then suspended to one end until the maximum degree of torsion which it is proposed to give to the spring (180deg.) is reached. The motor is rotated at the same time, so as to keep the lever in a horizontal position. The arm of the lever is 15·92 centimetres long, so that each kilogramme applied to the end of the

* From *L'Electricien*.

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arm of the level is equal to 1 kilogramme metre of work per revolution. Opposite the place occupied by the needle on the dial, the weight in kilogrammes applied to the end of the lever is marked. The lever is then unloaded, and the graduation continued.

After having tried several methods, M. Trouvé has adopted as a speed-counter an apparatus identical with that we have just described. The instrument employed by him is based upon the principle that in order to turn a rigid fan in the air it is always necessary to exert the same couple for the same angular velocity. This tachometer is shown at L in the figure.

When the apparatus is used as an absorption dynamometer, one end is fixed to the motor by means of a Cardew coupling, and the other is connected to a fan of suitable size. A graduation of the dial such as described above will enable us to read off the couples exerted. By means of a speed-counter we can estimate the angular velocity which it is necessary to give to the apparatus in order that the same needle may indicate couples of 1, 2, and 3 kilogrammetres. The product of these two indications will give the power developed. We can, therefore, mark directly on the dial the value of the power developed in the case of a given fan. Three curves obtained once for all enable us by one single observation to determine the angular velocity, the couple exerted, and the product of these two, the power. By means of different fans we can vary the power absorbed between wide limits.

The simplicity of this transmission and absorption dynamometer is a guarantee of good working, and the altogether negligible friction of the measuring organs is a reason why the indications should be exact.

RELATIVE AMOUNTS OF AVAILABLE VOLTAIC ENERGY OF AQUEOUS SOLUTIONS.*

BY G. GORE, F.R.S.

In the present research the amounts of voltaic energy were those excited by means of a zinc and platinum couple in solutions of the substances in distilled water, the electromotive force of the couple in the water alone, before addition of the substance, being equal to ·98 volt, and balanced either by a suitable thermo-electric pile (see *The Electrician*, Vol. XII., p. 414), or, much more conveniently, by an exactly similar couple in distilled water, and the substance then added in minute quantities at a time to the water of the testing cell until the needles of an ordinary torsion astatic galvanometer of 100 ohms resistance, included in the circuit, visibly commenced to move, the current from the testing cell being usually the strongest. The minimum amount of electromotive force required to move the needles was about ·00013 volt. For greater convenience in working, the two pairs of metals were attached to a frame and rack work, so as to slide up or down, and be supported either in or out of the liquids (see *The Electrician*, 1889, Vol. XXIII., p. 171). N.B.—The measurements do not include the amounts of voltaic energy lost by "local action." Each amount of energy given represents the proportion of water required to dilute one part by weight of the substance in order to make the effect upon the needles sufficiently feeble: it is also the average of two numbers, viz., one of the proportion of substance which was barely strong enough to visibly move the needles, and another of the proportion which just visibly produced that effect; the needles were observed through a magnifying glass. As the amount of mechanical work done by the current upon the needles at the point of measurement was the same in all the cases, and as all the essential conditions of action were unchanged, except the chemical composition of the liquid in the testing cell, the numbers given represent approximately the relative amounts of available voltaic energy exerted between the zinc and the respective substances in solution at the given temperatures. Polarisation was sufficiently excluded by heating the platinum to redness when necessary; the solutions used, however, were usually so extremely weak, and, by much experience in working, the point of measurement could be so quickly and nearly arrived at, that very little polarisation occurred.

As in some cases the numbers obtained varied greatly with small changes of chemical composition of the substance, they are, of course, subject to the influence of any impurity present; this influence has been separately examined. The substances employed were very generally of a high degree of purity, and any that were suspected to be impure were analysed; a large number of them had been analysed and purified from time to time. Distilled water was used in making all the solutions. In the cases were minus numbers are given the electromotive force and voltaic energy of the testing cell was *less* than that of the opposing one excited by water alone.

* Read before the Birmingham Philosophical Society.

In order to detect the influence of any invisible film of oxide, &c., formed upon the surface of the zinc in the active cell, in every instance after the determination, the active cell was emptied of solution, refilled with distilled water, and the couple immersed in the water to ascertain whether it exactly balanced the couple in the idle cell. If the two were equal, it was concluded that no interposing film had formed upon the zinc. The fact of the method being nearly a null one reduced largely the chances of polarisation.

It is evident that in such experiments only rarely, and by what is termed "accident," are the two opposing electro-motive forces perfectly equal, the particular number of pairs of the thermo-electric pile is either a little too strong or a little too weak to exactly balance the cell; or, if two cells are employed, they are never exactly alike in potential. Further, as it is highly probable that even the very smallest proportion of an acid, &c. (insufficient to move the needle), when added to the water, begins to alter the potential (see "Effects of Different Positive Metals, &c.," Roy. Soc. *Proc.*, Vol. XLIV., p. 368); then, with all proportions of substance below that which visibly moves the needles, the two opposing forces appear to be balanced when they are not so. Also, the further addition of acids, &c., not only alters the potential, but diminishes the total resistance until sufficient current passes to produce a visible movement of the needles. The question whether the two forces were sufficiently nearly balanced when they showed no effect upon the needles was tested by immersing the usual zinc wire and platinum sheet couple in distilled water, balancing its potential through the usual galvanometer by means of that of a small Daniell's cell plus a sufficient portion of the thermo pile, and allowing the arrangement to remain undisturbed during fifteen minutes to develop polarisation, and visibly change the balance; no such effect took place. In another trial the same couple was immersed in a solution of four grains of potassic chlorate and 465 grains of water; then, carefully balanced by the thermo pile and allowed to remain fifteen minutes, the balance was again not visibly altered. The extreme sensitiveness of the method is a further guarantee that the two forces were sufficiently nearly balanced when they showed no effect upon the needles.

In order to test whether the change of resistance, due to addition of acid, &c., to the couple in distilled water below the "minimum point" of change, had any effect upon the "minimum proportion" of the substance required to visibly alter the balance, and as one of the sources of resistance was the limited surfaces of the metals, I took plates of the two metals, each 3·5 centimetres wide, and immersed them 5·0 centimetres deep, and 1·0 centimetre apart in the water, and then balanced the potential of this cell through the ordinary galvanometer by that of the usual one with the smaller pieces of metal. On then adding chlorine to the water of the larger couple, the "minimum proportion" was found to lie between one part in 1,110,660,000 and 1,300,000,000, the same as with the ordinary couple. By other special trials of the same kind with hydrochloric acid and with potassium chlorate, the minimum proportions of substance required were found to be the same as when the usual sized pieces of metal were employed. From these results I conclude that the change of resistance due to change of size of metal had no conspicuous effect.

In each of the instances of measurement of energy of complex substances the amount of energy given is that of the true or definite "solution compound," not containing any excess of either ingredient. In order to ascertain the real combining proportion and formula of each complex substance, additional measurements were in every instance made, both of the amount of energy of the compound with an excess of one of its ingredients, and with an excess of the other (*see* Roy. Soc. *Proc.*, Vol. XLV., p. 265; also *Proc.* Birm. Philos. Soc., Vol. VI., Part 2; *Ibid.*, Vol. VII., Part 1, *Chemical News*, April 10, 1890). The true "solution compound" was in every instance indicated by a depression of voltaic energy, and the amount of energy in every case increased distinctly on adding a limited excess of either ingredient. The combining proportion indicated by the balance was in every case the same as the ordinary chemical equivalent. The list* includes about 324 of such compounds.

In the case of isometric solutions, caution must be exercised in accepting the numbers of one of each couple, the one having the largest amount of energy, because that one is usually unstable, liable to decompose, especially by elevation of temperature, and become converted into its isomer, with simultaneous loss of voltaic energy, KI+Cl (voltaic energy=2,045,138), and KCl+I (I=64,536) constitute an example (*see* Roy. Soc. *Proc.*, Vol. XLV., p. 440). $Na^2SO^4+2HNO^3$ and $2NaNo^3+H^2SO^4$ is another (see *Phil. Mag.*, October, 1889, p. 290).

The plus sign in the formulæ is used to separate the equivalent quantities. The amounts of voltaic energy are relative, not actual.

* The greater part of this list, owing to its length, has been omitted; it will, however, appear in full in the *Proc.* Birm. Philos. Soc.—ED. *E.*

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Amounts of Voltaic Energy with a Zinc and Platinum Couple.

No.		Temper. at Degrees C.	Average Voltaic Energy.
1.	Chlorine	at 11	1,282,000,000
2.	Bromine	13·7	81,022,500
3.	HClO	16	19,635,286
5.	HCl	16·5	9,344,092
11.	H^2SO^4	19	3,900,941
12.	$H^2SO^4 + 2$ HCl	14	3,804,909
13.	Iodine	13·5	3,310,985
28.	Acetic acid	13	1,585,760
31.	H^2SO^3	15	1,328,779
50.	KCl	8	699,803
59.	Formic acid (H^2CO^2)	19	545,535
82.	NaCl	15	207,589
124.	KBr	9	66,909
134.	Tartaric acid + H^2SO^4	10	56,717
136.	KBr + I	13	54,826
137.	Potash alum	15·5	54,536
155.	Citric acid	22	36,597
156.	Chrome alum	19	35,902
161.	NaCl + HCl	17·5	31,083
172.	NaBr + I	14	25,709
186.	$ZnCl^2$	17	20,336
187.	$K^2SO^4 + 2$ HCl	15	20,125
188.	$KHSO^4$	16	18,298
189.	$K^2SO^4 + H^2SO^4$	17	18,016
192.	KI	19	16,361
196.	Ammonia alum	18	15,857
197.	AmCl	13·5	15,069
201.	$ZnSO^4$	22	13,654
216.	Oxalic acid	15	9,450
225.	KI + KCl	10	7,571
236.	NaCl + KCl	20	5,959
249.	K^2SO^4	12	2,274
253.	Na^2SO^4	13	2,020
291.	$MgSO^4$	20	216
295.	$CaCl^2$	16	181
365.	Water	16	0
366.	Alcohol (anhydrous)	15	−6·65
367.	Urea	19	13·6
374.	Cane sugar	15	67·8
378.	Carbolic acid (solid & colourless)	19	90·5
395.	Caffeine (perfectly white)	18	416
407.	Nicotine (brownish)	19	3,159
408.	Picric acid (variable)	17	3,585
417.	CaO	18	52,777
423.	Methylamine	19	241,019

The above order may be viewed as that of a volta tension series of liquids with a zinc platinum couple.

The influence of the kind of solvent upon the amount of voltaic energy is shown by the measurements made with chloride of calcium; this substance when dissolved in distilled water at 16°C. gave 181; in 7 volumes of glycerine and 3 of water at 18°C., 41·9; and in nearly anhydrous alcohol at 20°C., 23·4. A chemical analysis of the caustic soda employed, calculated for the anhydrous substance, gave 80·04 per cent. of NaHO and 19·96 of Na^2CO^3; and of the caustic potash, 77·6 KHO and 22·4 K^2CO^3. With a very pure sample, containing 97·64 per cent. KHO and 2·36 K^2CO^3, the amount of energy was −252,533. A sample of potassic cyanide, containing 92·11 per cent. of KCy, gave −148,737. It is interesting to notice that cane sugar acts as a dyad in uniting with common salt; the action, however, is not very distinct.

In this table the elementary halogens head the list; then follow the acids, acid salts, neutral salts, alkaline salts, and finally the alkalies, and complex compounds of alkaline reaction. Picric and carbolic acids are, however, amongst the substances yielding minus numbers. Strong solutions of carbolic acid, ammonia, or potassic cyanide (above 1 part KCy in 3,229 parts of water), when balanced by equal electromotive force, gave *plus* numbers.

The great decrease of electro-negative energy attending increasing complexity of chemical composition of the compound is strikingly shown by some of the mixtures employed, and is usually greater the nearer the aggregate of molecules approaches that of a mechanical mixture, and suggests the question whether the dissolved alkalies are usually composed of more complex molecules than the dissolved acids, which are nearly all of them near the other end of the scale.

By arranging well-known chemical groups of substances in series, with their amounts of voltaic energy, the latter forms, in various cases, a regular gradation of values; for instance, chlorine with potassic fluoride, chloride, bromide, and iodide; bromine with those salts; iodine with potassic chloride, bromide, and iodide; chlorine with sodic chloride, bromide, and iodide; also either potassic fluoride, chloride, bromide, nitrate, chlorate or iodate, with chlorine, bromine, and iodine; or sodic chloride with those elements.

The electromotive force of zinc in chlorine water, with platinum in solution of potash, the liquids being one-fourth saturated and separated by a parchment diaphragm, as determined by balancing it by the thermopile, was 1·2,644 volt. With platinum in each liquid it was ·944 volt, and with zinc in each liquid ·7,067 volt, the liquids in each case being at 18°C.

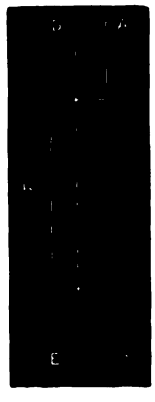
THE PHYSICAL SOCIETY.

At the meeting of this Society, on June 20th, Mr. C. V. Boys read a Paper

On the Measurement of Electro-Magnetic Radiation,

by himself and Messrs. A. E. Briscoe and W. Watson.

When Mr. Gregory described his new Electric Radiation Meter on November 1, 1889 (*The Electrician*, November 8, 1889, p. 16) one of the authors said that the observed effects might be due to some cause other than expansion by heating, and that if it was a true heating effect it might be measured thermally. The present communication describes experiments undertaken to investigate the question. The first method employed was developed from the idea that if two fine wires be placed near together and both act as resonators to a primary oscillator, the electro-dynamic attraction caused by the electric currents up and down the wires, and the electrostatic repulsion between the charges on them, might result in the relative motion of the two wires. From theoretical considerations, based on the assumption that the currents are harmonic in time and space, the authors inferred that the electro-dynamic effect would preponderate at the middle of the wires, whilst the electro static repulsion would be greatest at the ends. To cause the attractions and repulsions to conspire, cranked resonators A B C (*see* Figure) were



made; one was fixed and the other suspended by a quartz fibre, to turn about a middle line D E. These were enclosed in a glass vessel, and on starting the oscillator a turning movement was observed in a direction opposite to that expected. This motion was eventually traced to the electrostatic influence of the oscillator; for although the imperfectly conducting surface of the glass acted as a perfect screen from such action when the potentials of the oscillator were varied slowly, it did not do so for changes occurring about 500 million times per second. After adopting means to avoid this disturbance, and constructing lighter resonators, the experiments were repeated with negative results. From the dimension of the quartz-fibre used, it was estimated that a force of 158-millionth of a grain could have been detected with certainty. This would have corresponded to about $\frac{1}{300}$th of an ampere in each resonator. It is hoped that by further increasing the sensitiveness of the apparatus and using parabolic reflectors the effect sought for may be detected.

In the second method of attacking the subject, a Joule's dynamic air-thermometer was employed. This consisted of a glass tube, with a partition along the middle, extending nearly to the ends. If one side of the tube be warmed, convection currents circulate, and deflect an index placed in the stream. A small mirror suspended about one edge and counterpoised, was used for an index, and was so sensitive that it was impossible to get the air still enough by any ordinary method of screening. However, by the ingenious device of putting the thermometer within a larger tube kept rotating by clockwork, the difficulties were surmounted. A double wire, placed in one side of the thermometer, served as resonator, and on starting the oscillator a large deflection resulted. A similar deflection was caused by applying about $\frac{1}{3}$ of a volt to the ends of the wire. This proved that the effect observed by Mr. Gregory is due to heating. The least rate of heating observable with the air-thermometer was found to correspond to one calorie (gramme-water centigrade) per 24 hours in the whole tube, or one calorie per centimetre of wire in 103 days.

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DISCUSSION.

Dr. LODGE asked Sir William Thomson whether, when electric pulses travel along parallel wires with the velocity of light, any action could exist between them, for two charged spheres travelling together at that velocity exerted no mutual attraction or repulsion.

In reply, Sir WILLIAM said he was inclined to think Mr. Boys' treatment of the subject was in the main correct; but it was quite possible that, at such velocities, the ordinary laws might be modified by the fact that the time taken for the force to be propagated from wire to wire was comparable with that required for the pulse to travel the whole length of the wire. As an example of the peculiar effects of rapid discharges, he said he had seen two copper wires which had been flattened against each other by lightning.

Mr. BOYS thought that in his resonators a condition analogous to stationary waves would exist, for the pulses were reflected from the ends.

Dr. LODGE said he had that afternoon observed the action of parallel strips when Leyden jar discharges were passed through them. The strips gave a kick at each discharge.

Mr. GREGORY mentioned that in trying to increase the sensitiveness of his meter so as to measure the variation with distance, he had found that two resonators in proximity interfered with each other. He had, however, succeeded in increasing the sensibility about five-fold.

Prof. WORTHINGTON asked if it was possible to measure the energy of the oscillator, and also whether the quantity caught by the resonator could be estimated from the solid angle it subtended at the source of energy, wherever that might be.

Prof. PERRY considered it easier to infer the energy of the source from that received by the resonator.

Dr. LODGE said the energy of the source could be easily measured. The power radiated was enormous whilst it lasted, vastly exceeding that of tropical sunshine; and if it could be made continuous, the apparatus would soon be red hot. The energy radiated, he said, converges on the resonators, and hence the solid-angle method of estimating the amount received would be erroneous. Moreover, the source was not at the oscillator, but at a quarter wave-length from it, and most of the energy returns to the oscillator; only a small fraction is splashed off and sent into space. Small oscillators radiate powerfully because the quarter wave-lengths are small, whereas the slow oscillators or alternators used commercially, radiate very little of their energy. The exact law of variation of intensity of radiation with distance was rather complicated, but the theory had been completely worked out by Stokes in 1848.

Mr. BLAKESLEY thought the energy that returns to the oscillator would be available for subsequent radiations.

Dr. LODGE pointed out that wires or other resonators placed within the quarter-wave-length would intercept part of the returning energy.

Two communications, "Notes on Secondary Batteries," by Dr. Gladstone and Mr. Hibbert, and "An Easy Rule for Calculating Approximately the Self-Induction of a Coil," by Prof. J. Perry, were taken as read.

In the first of these the authors show cause for believing that the beneficial effect produced by adding sodium sulphate to the ordinary electrolyte is due to its power to diminish local action between the electrolyte and different parts of the lead plates. As regards the chemical actions which take place during the working of ordinary cells, they see no reason to doubt the view put forward by one of them in 1882, that the substance produced in the voltaic reaction is ordinary lead sulphate, $PbSO_4$. They also conclude that the high E.M.F. of a cell immediately after stopping the charging current is due to the inequality of acid strength near the two plates, and the gradual fall of E.M.F. is caused by the equalisation of strength produced by diffusion.

Prof. Perry's rule relates to hollow cylindrical coils, and is expressed by the following formula:—

$$\text{L (in secohms)} = \frac{n^2 a^2 \div 10^7}{1{\cdot}844\,a + 3{\cdot}1\,c + 3{\cdot}5\,b},$$

where n = number of windings,
a = mean radius of winding in centimetres,
b = axial length,
c = radial depth of winding.

and b **and** c **are less than** $\frac{a}{2}$.

The time-constant of such a coil is given in terms of the volume of copper (V′) in cubic centimetres by

$$\frac{L}{R} = \frac{V' \div 1000}{\cdot 728\,a + 1{\cdot}33\,c + 1{\cdot}5\,b},$$

and the conditions for making this small are pointed out in the Paper.

Morgan's Electric Police Signal System.—A practical demonstration of this system is about to be made in the south-west of London; permission has already been obtained for the erection of thirteen signal lamp-posts, which will be connected by underground wires with the central depôt at one of the police stations. The apparatus is being made in Newhaven, Con., and operations will begin as soon as it arrives in England.

CENTRAL LONDON RAILWAY BILL.

HOUSE OF LORDS.—THURSDAY, June 19th.

On the motion for the second reading of the Central London Railway Bill,

The BISHOP of LONDON rose to move, as an amendment, that the Bill be read a second time that day six months. It was not usual, he said, for Bishops to oppose a railway Bill, but he was sure the indulgence of their lordships would be extended to him in this case on the ground that he considered the Bill involved danger to St. Paul's Cathedral. The proposal in the Bill was to carry a railway which would approach very near the Cathedral, and the station came within about 70 yards of the north-east corner of the Cathedral. Therefore it became a question of importance to consider what the effect would be on the stability of the Cathedral. From the records they had evidence that there was a considerable quantity of brick earth under the Cathedral, and under that sand and gravel, and lower down the London clay. Sand and gravel were water-bearing strata, and the fear was that the water might be drained away from the sand and gravel, which might sink. Considering the weight of the vast edifice it was feared there would be danger in any case. Moreover it was proposed to make a large station between the railway and St. Paul's, and it was obvious that the sinking of a shaft to the level of the railway in the construction of this station involved a serious risk. It was a noteworthy fact that the engineer in charge of this work was the same engineer who had charge of the London and Southwark Subway, and that subway was being constructed in the very manner in which this railway was proposed to be constructed. Well, the engineer stated in evidence in support of the Bill for the London and Southwark Subway that there would be no damage to the neighbouring houses; but he found that the subway had done mischief almost all along its extent. It was not a matter which ought to be decided on mere speculative evidence. Surely, if there was a doubt, they ought to give the benefit of the doubt to St. Paul's Cathedral. If any injury were to happen to that great fabric could a greater disgrace to the Parliament of this country be conceived than that they should have consented to bring very serious ruin upon one of the glories of the metropolis of England in order that people might be saved 15 minutes in coming from Bayswater to Cheapside? He appealed to their lordships to resist any speculation which might have such disastrous consequences.

VISCOUNT POWERSCOURT said he doubted very much whether any settlement of earth which might be caused at the distance of 250ft. from the Cathedral could affect the foundations of St. Paul's.

LORD SUDELEY thought that the motion was a most unusual one in regard to a Bill of this importance. Indeed, he believed it was almost without precedent, and he did not think a case had been made out. He would suggest that the Bill should receive a second reading, and then go to a Committee, where it could be thoroughly inquired into.

The EARL of MEATH said that when an attempt was made in the House of Commons to throw out the Bill on the report, its opponents did not go to a division.

VISCOUNT CRANBROOK suggested that they should let the Bill go to a Committee, and if the Committee were to make a special report whether, in their opinion, there would be danger to the Cathedral, and state their reasons, their lordships would have some grounds on which to proceed. At present they were acting in the dark, but if they had a report before them they could see whether the grounds were sufficient for proceeding with the Bill. If, on the other hand, the Committee came to the conclusion that there was no ground for going on with the measure, and that the preamble was not proved, of course the Bill would not come back to them at all.

EARL FORTESCUE thought it extremely undesirable, except in cases of the clearest principles, that either House of Parliament should attempt to discuss points of engineering or deal with matters which could only be satisfactorily settled before a Committee.

The BISHOP of LONDON said he should be glad to accept the advice of the noble viscount the Lord President, but he reserved to himself the right of opposing the further progress of the Bill, if it should appear to him that the decision of the Committee was not in accordance with the wisest course.

The amendment was then withdrawn, and the Bill was read a second time.

The time for petitioning in the House of Lords against the Central London Railway Bill has expired. From the petitions deposited, it is found that 19 petitioners will, unless previously settled with, appear in opposition to this Bill, which is just over half the number who lodged petitions in opposition when this Bill was before the House of Commons. Among the opponents are the Corporation of London, the Commissioners of Sewers, the London County Council, and the vestries of St. Marylebone and Paddington. The Railway Companies opposing are the Metropolitan and London, Chatham and Dover, whilst the remaining petitioners are landowners or others interested in property. Among these are the Dean and Chapter of St. Paul's, the owners and occupiers of property in Oxford-street, Cheapside, and Poultry, the Duke of Westminster, Viscount Portman, Sir James Bacon, Messrs. Trollope, the Paddington Estate Trustees, trustees of the late Duke of Portland, and the Ecclesiastical Commissioners.

Copper.—The prices of raw copper are steadily advancing, and stocks are being very considerably reduced, the visible supply showing a reduction of slightly over 6,000 tons from the 1st to the 15th inst. Chili bar quotations range at close upon £60

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TELEGRAPH RATES TO AUSTRALASIA.

The following additional letters on the above subject from *The Times* of June 14th and 16th complete the correspondence, part of which appeared in our issue of 13th inst. :—

TO THE EDITOR OF "THE TIMES."

Sir,—In answer to Mr. Henniker Heaton's letter, which you publish to-day, I beg to state that he obtained possession of the Articles of Association of the Pacific Telegraph Company from my colleague in the matter, Mr. R. C. Want, under the pretext of obtaining Mr. Reid's signature, and signed them himself, in defiance of an assurance upon his part to Mr. Want that he would not do so. His signature was very nearly the occasion of the withdrawal of all my friends who had already signed, who fully share my conviction that any scheme with which Mr. Henniker Heaton's name may be associated is not likely to be favourably received in Australia. It may amuse Mr. Henniker Heaton to imagine that the bare fact of his signing the articles of the Company diffuses a talismanic glamour over its existence and smooths all obstacles in its path. I can assure him, from eight years' residence in Australia and four years' experience as secretary of the Company, that nothing of the kind is the case.

In the very laborious work undertaken and carried out by the Company in compiling statistics, in formulating proposals laid before the Colonial Conference, in establishing colonial agencies, in inducing Her Majesty's Government to survey the proposed cable's route—in all this Mr. Henniker Heaton, from the day of his signing the articles, has borne not the remotest share. He is quite content to let others work, while he appropriates as much of the credit as he can. I have only to add that, while Mr. Henniker Heaton became a shareholder in the Pacific Telegraph Company in the manner above set forth, he continues to be one only by the courtesy of the Directors, since he has never even paid for the one £10 share for which he subscribed.—I am, Sir, &c.,

HAROLD FINCH-HATTON, Secretary.

34, Clement's-lane, June 12th.

TO THE EDITOR OF "THE TIMES."

Sir,—I must compliment Mr. Harold Finch-Hatton on his plausibility and his dexterity. He now does not deny that I was the founder and originator of my Pacific Telegraph Company, and that he wilfully suppressed my name and the fact from the public that I had anything to do with the Company. The amalgamation with Mr. Want's Company, after that gentleman had returned from Australia, is also not noticed. The simple explanation of the new charge levelled against me is that Mr. Want and I agreed not to sign our names, but the gentlemen associated with me insisted on my signing, as I had induced them to go into the affair. Thereupon Mr. Want also signed. Mr. Harold Finch-Hatton says I did not contribute to the funds. He ought to have added the words "since Mr. Finch-Hatton became secretary." The fact is I have expended (as explained at the great public banquet given to me in the Town Hall, Sydney, on the occasion of my visit three years ago, at which the Mayor of the city presided, and for the first time the whole of the members of the present and late Governments met to do me honour) no less than £2,500 in advocating cheap postage and telegraphs to all parts of the Empire. But when I found that that expensive gentleman Mr. Finch-Hatton was taking a prominent part as secretary in our joint company, I declined to subscribe a farthing, and strongly dissuaded my friends from subscribing. With good intentions and many good qualities, he is not a financial genius ; and that a man in such a position certainly ought to be.—Very faithfully yours,

Carlton Club, June 14th. J. HENNIKER HEATON.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 13, 1890.

Gas Mains in New York. — Considerable excitement was caused the other day by an accident which shows the importance of immediate legislative action controlling the always more or less lawless gas companies. It is notorious that the gas mains in the lower part of New York City leak at innumerable joints, pouring out quantities of gas to permeate the earth with its noxious odours and accumulate wherever there is an opportunity to cause explosions. One of these many leaks chanced to be at the corner of Broadway and Fulton-street, one of the most crowded sections of the city, where an overturned lantern ignited the gas. The result was an immediate explosion in the subway beneath, seriously injuring one of the workmen, and then a column of flame shot up from the opening, gathering in volume as the intense heat started the neighbouring joints in the gas main. For 18 hours the flames poured into the air, threatening danger to passers-by, filling the adjacent buildings with noxious fumes and heating neighbouring electric conduits so as to completely cripple the service. After many hours of exertion the mains were blocked sufficiently to allow of smothering the flames. In certain portions of the lower part of New York these gas leaks have become so serious that a crowbar thrust into the earth and then withdrawn starts a stream of gas that may be only too readily ignited. There seems to be a singular carelessness on the part of the authorities in allowing such leaks to exist. If the electric light companies were to show symptoms even of the same amount of carelessness they would have to go out of business ; but the public does not seem to realise that while a poor electric conduit only damages the company, a leaky gas main is a continual peril to life and property in the vicinity.

Electrical Execution.—The case of Kemmler, condemned to die by electricity, is again called to public attention from the fact that Judge Wallace has just vacated the writ of *habeas corpus* which delayed the execution appointed for last May. The general opinion seems to be that he will be executed in the early summer by the means prescribed by law.

The Direct Conversion of Heat into Electricity.—The country papers just now are full of reports of a method of converting heat directly into electricity, said to have been invented by a young man who hails from the State of Maine. The reports are mainly remarkable in their omission of all details that might lead to any possible information concerning the process, and it is altogether probable that this is only one of the numerous *canards* that float around in quasi-electrical circles.

The Prospects of Electric Traction in New York.—Governor Hill's non-signature of the Cable Bill gives New Yorkers one more chance to have genuine rapid transit, provided that the Manhattan Elevated Railway magnates do not succeed in smothering any attempts made in this direction. There is an admirable opportunity for a four-track underground system, reaching the entire length of Manhattan Island, and nothing short of it will ever relieve the city from the pressure to which it is now subjected. There is great talk of an enterprise of this sort being inaugurated shortly ; but there are plenty of political stumbling blocks in the way of success of such a plan, and it is much to be feared that its day is not yet.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *June* 20, 1890.

The use of electricity for lighting is really beginning to increase very materially in Scandinavia ; more in Sweden, I think, than in Denmark and Norway, although in these countries, too, people are commencing to go ahead in this respect. In the first-mentioned country several small towns have adopted electric lighting for the streets, *i.e.*, Hernösand and Östersund ; and others have decided upon it, among them being Helsingborg and Sundsvale, where the installation is in course of erection. Siemens and Halske, Berlin, have secured the contract for the Helsingborg installation. In this town underground cables will be adopted for the more central parts of the town—the first instance in Sweden, I believe, of underground cables for lighting of a town. The Stockholm Gas Works have recently purchased some well-situated property at a price of 360,000kr. for the purpose of turning it into a central electric station, which will be proceeded with without delay.

In Copenhagen the Corporation has also bought some property in the centre of the town for their central station. In this town electric lighting appears to be coming very much to the fore ; and the applications to the Corporation for electric light installations have been so numerous that an extension of the originally contemplated plan will, no doubt, be necessary. Danish electrical engineers are now very busily engaged in securing the orders for fittings, &c. In Gothenburg the town has just refused an offer from the private lighting Company to sell their installation ; but in other towns the civic authorities do not seem disinclined to take up the matter of electric lighting on their own account. Several Norwegian towns, including Christiania and Skien, will adopt electric lighting on a larger scale. The Elektrisk Bureau of Christiania, which has already completed a very large number of installations, have secured the contract for the installation at Gaustod Lunatic Asylum. This will consist of machine-power for 520 and accumulator battery for 200 incandescent lamps of 16 candle-power. This year about 500 lamps of 10, 16, and 32 candle-power will be installed in the various

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buildings belonging to the asylum itself, and later on the installation will be extended to the out-buildings.

In Sweden a large number of electric installations in industrial establishments have been completed of late, prominent among which are a good many sawmills. Whenever new industrial works are erected, or extensions of old ones made, it is almost a matter of course that electric light is adopted.

If electric lighting can be said to have made satisfactory progress, everybody must admit that the telephones are making a marvellous advance. In no country in the world, I fancy, has the telephone come into more general use than in Sweden. People who in England would not dream of having what they would consider a luxury, would in Sweden little think of doing without; it has there almost become a necessity. The Stockholm General Telephone Company is a model institution, to which I have had occasion to refer in previous letters. Their report for last year contains several items of interest. It appears that co-operation has been secured with the telephone companies in the towns of Upsala, Vesterås, Norrköping, and Nyköping; and further arrangements of co-operation also with the State telegraphs and telephones are pending. During 1889 the Company installed 825 telephone connections for new subscribers in Stockholm, and 195 subscribers have, for various reasons, given up the telephone. The total number of subscribers was at the beginning of the year 4,556, and at the close 5,186. There were direct lines, 2,820; telephone with two-line automatic exchanges, 514; telephone with five-line automatic exchanges, 949; lines at country stations, 216, &c. In addition to these, 22 telephones are in connection with the Company through the police telephone station, and 54 through the State telegraphs. The total number of conversations during the year amounted to 10,535,056, averaging 32,312 conversations per day, and 6·71 conversations per subscriber per diem. The number of telephone clerks employed was at the end of the year 98. The length of wire in the Company's connections was 9,790 kilometres. The total number of hands employed was at the end of the year 173. In addition to the Stockholm business the Company has at Söderhamn an installation with 342 subscribers, and at Jönköping one with 144 subscribers, both of which have shown material increase during last year. The net profits of last year's working amounted to 64,780kr. (1kr. = 1s.) The shareholders get an 8 per cent. dividend, and 15,000kr. are added to the reserve fund, and smaller sums added to various other funds.

Negotiations have for some time been pending between the Stockholm Corporation, the State telegraphs, and the Telephone Company about carrying underground telephone cables through the streets. Co-operation will also be arranged between the State telegraphs and the two telephone companies; but the question has been a difficult one to settle on account of the various conflicting interests.

The first electric locomotive in Sweden has recently been imported from New York by the Wenström and Granström Electric Power Company at Arboga; it is intended for the Boxholm Electric Railway.

THE PLYMOUTH SHOW.

The fifty-first country show of the Royal Agricultural Society of England has been held during the current week at Plymouth. As in previous years, we have to record an almost total absence of electrical machinery and exhibits; although from the fact that a few exhibitors put electrical manufactures amongst their exhibits evidence is not wanting that some day the Council of the Society will rise to the occasion, and make an effort to prove to the large numbers who visit the Show that it is possible for agriculturists, equally with other sections of the community, to utilise electrical machines and to take advantage of discoveries and inventions which are now so freely used by all classes. Amongst the exhibits at Messrs. J. Armfield and Co.'s Stand are a 5-unit and a 3-unit self-regulating dynamo, and a ¼ horse-power electric motor, all made by Mr. Veale, of St. Austell, Cornwall, and exhibited specially to show their adaptability for driving dairy and farm machinery; and Messrs. Priestman's show includes a complete electric lighting plant, comprising 30-light dynamo, 34 accumulators, together with all the necessary fittings, cables, switches, &c., and a ¾ horse-power electric motor, the whole manufactured by Mr. F. M. Newton, of Barton Grange, Taunton.

Messrs. John Fowler and Co. (Limited), of Leeds, show a 12 horse-power horizontal compound engine, fitted with automatic expansion gear on both cylinders, controlled by one governor, and specially constructed for electric lighting and where steady running is essential. Messrs. Robey and Co. show, amongst a number of engines exhibited, a high-speed vertical engine, specially suited for small electric light installations, ship lighting, &c., the engine having a working pressure of 80lb. Messrs. Francis Morton and Co. (Limited) have a fine display of their well-known manufactures. Messrs. Ransomes, Sims and Jefferies, in an exhibit consisting of 42 items, show a 10 horse-power compound "Undertype" engine, with patent automatic governor expansion gear, constructed specially for driving electric light machinery.

Messrs. Davey, Paxman and Co. exhibit two steam engines of the portable type, which have been selected by the jurors of the Show to drive the various machines sent for competition. One is an 8 horse-power compound engine, and the other an 8 horse-power single cylinder engine. Messrs. Davey, Paxman and Co.'s great experience in the manufacture of compound steam engines has again received recognition in the selection of their engines by the jurors, as above mentioned. It is one of the firm's contentions that first-rate results can be obtained with compound engines working without condensers; and the performance of the compound engine now under consideration certainly goes to verify their statements on the subject. The pattern and construction of the engine are especially worth careful observation. It is complete in itself, being built on a steel channel frame, bolted to a bracket on the boiler. By removing a few bolts the engine and frame can be lifted from the boiler, and fixed and worked separately. This design undoubtedly displays many features of considerable interest and merit. Both engines are fitted with Paxman's automatic gear, which is well known for its simplicity and effectiveness in controlling engines used for the electric light at the various exhibitions where Messrs. Davey, Paxman and Co. have had so many installations under their control. This firm also exhibit a 16 horse-power "Undertype" engine, and a girder engine, large numbers of the former of which are turned out by the firm every year. Another feature of this firm's exhibit is the latest patent vertical boiler, called the "Essex," to which they have devoted much attention, with the result that they have succeeded in designing and making a thoroughly economic vertical boiler. The construction of the boiler is noticeable; and to render explanation simple, Messrs. Davey, Paxman and Co. show the tube division of the boiler, from which it can be seen that the tubes pass from a wedge-shaped chamber on one side of the boiler to a similar chamber on the other. These are curved to a radius somewhat greater than that of the boiler. A neck connects one of these chambers with the firebox, and to the other one is attached the funnel. They are both provided with a door, so that the tubes can be cleaned or replaced with facility. The shape of the flues causes a centrifugal action in the hot gases, which brings each portion into direct contact with the tube surface, so that the highest efficiency is obtained from the heating surface, while at the same time good circulation of the water is secured.

Messrs. Marshall, Sons, and Co., have on view a 6-horse power portable steam engine, constructed for a working pressure of 80lb.; and a compound stationary steam engine of 12-horse power, placed under a boiler of the locomotive type, with patent automatic expansion-valve gear, and sight-feed lubricator to high-pressure cylinder. Mr. E. S. Hindley shows a 3 horse-power vertical engine combined with a vertical tube boiler, for 60lb. pressure to the square inch; and an 8 horse-power horizontal engine on cast-iron foundation, the cylinder lagged with mahogany and brass bands. Messrs. Brown and May have on view a Knight's patent portable paraffin engine of 1 horse-power nominal, for which they claim that any mineral oil can be used, and only one sort of oil need be kept by the purchaser. This firm also exhibit, amongst other engines, a 10 horse-power horizontal steam-engine, which is self-contained, and especially designed to work at its maximum power.

Messrs. Priestman Brothers (Limited) show a 11 horse-power Priestman's patent portable oil engine, mounted on wheels, with shafts, which drive one of Wallis and Steevens' threshing machines, for which purpose it appears to be very suitable; a 5 horse-power Priestman's patent portable oil engine, mounted on wheels, with shafts, &c.; and a 2 horse-power Priestman's patent horizontal oil engine, shown in connection with the electric lighting plant mentioned above. The makers inform us that they are busily employed with home and foreign orders for this latter type of engine.

Messrs. Crossley Brothers (Limited) have a fine exhibit of gas engines, including a new design high-speed electric light engine known as D size, which is specially arranged to run at 250 revolutions and to give seven revolutions on the pulley. The firm guarantee absolute steadiness for this engine, which drives direct on the dynamo, and they claim that it is unnecessary to attach to the dynamo a fly-wheel or disc, as is usually the practice. In addition to this special electric light engine, the firm show three horizontal "Otto" engines, and a gas engine and pump combined, an advantage connected with the latter being that when the pump is not in action the engine can be used for other purposes. Gas engines are also exhibited by Messrs. T. B. Barker and Co., who show a 7 horse-power and a 2 horse-power "Forward" engine, the latter of the new "Undertype" pattern, with automatic hot tube igniter; and by Messrs. Fielding and Platt, who have on view a 4-horse power and a 1-horse power "Fielding" gas engine, for

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which they claim advantages over many other engines in the market.

In addition to the exhibits mentioned above, which are chiefly situated in the department for machinery in motion, there are some excellent shows of lubricants and cylinder oils, belting, scientific instruments for food-testing purposes, the useful manufactures of the Sanitas Company, and some specimens of wood engraving, zincography, Nature-process work, and electrotyping, by Messrs. Dawson, Wilmer, and Clift.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—It will be seen by our advertisement columns that the Town Council of Winchester are prepared to consider tenders for the lighting of the streets of the City and Corporation buildings by electricity. Full particulars and conditions can be obtained at the town clerk's office, and tenders are to be sent to Mr. Walter Bailey, town clerk, on or before 1st September next.

——— The Local Board for the District of Carshalton invite tenders for the lighting of the district with gas, oil, or other illuminant, at per lamp, exclusive of the cost of columns, frames, and lanterns, for a period of twelve months from July 31st. Tenders, endorsed "Public Lighting," and addressed to the Chairman of the Board, are to be deposited at the Board Offices, High-street, Carshalton, by 12 o'clock noon on Wednesday, July 9th.

——— The General Direction of Posts and Telegraphs in Madrid will receive, up to Thursday, July 10th, tenders for the installation and maintenance of a telephone exchange at Linares, Prov. Jaen, Spain.

TECHNICAL JOURNALISM.—We have received from a gentleman occupying a leading position in the electrical world some interesting particulars of an application recently made to him by a journal claiming to have an enormous *clientèle* amongst railway companies, contractors, &c., &c., asking to be favoured with a description of a leading line of his manufactures, which the editor of the journal in question would be pleased to insert, subject to our correspondent's approval of the proof, on the condition that reprints of the article were supplied or that the article should afterwards appear as an advertisement in the said journal. Our correspondent further says that the specimen sent us is only one of a pile of letters he is constantly receiving from the same source. We regret that we are unable to do more than call attention to the matter in this indirect way, as, so far as we can see, the journal in question cannot legally be prevented from adopting this method of securing notice from circles which it would not otherwise reach. Our correspondent may derive consolation from the fact that he is by no manner of means the only victim of this system of touting. He can further rest assured that the journal which has thus importuned him is not a representative one, but is one which, even in London, is but little known and less respected.

THE TECHNICAL AND GENERAL NEWS AGENCY.—This agency has been formed to supply cuttings from English and foreign technical and trade papers, for the use of the press and electrical and engineering firms. The temporary offices are situated at 46, Cranmer-road, Brixton, S.W.

PARTNERSHIP DISSOLVED.—The Morgan Crucible Company, of Battersea, crucible manufacturers, has dissolved partnership, the business being transferred to a limited liability company.

THE WATKIN TOWER.—Some misapprehension exists as to the arrangements which have been made in connection with the proposed high tower for London. Although the prizes have been awarded nothing definite has yet been fixed as to the design which will be ultimately adopted, nor as to the site to be selected.

A NEW PRIMARY BATTERY FOR SURGEONS.—We have received particulars from Mr. Henderson, of Brazenose-street, Manchester, respecting his new primary battery, for which he claims simplicity and excellence of construction. The main details are such as are usual in batteries of this class—zinc-carbon elements in a solution of bichromate of soda and sulphuric acid; but an important feature is the arrangement of the connections, which are such as to allow of the six cells being arranged either in series (12 volts) for lighting purposes, or in mutliple series (6 volts) for cautery and other surgical operations. The current is 25 amperes per cell, and the battery is put in or out of action by a foot-lever. Care has been especially taken in the method adopted for attaching the carbons; the metal lugs are heavy, and after attachment the carbons are soaked in boiling paraffin and coated with a new impervious varnish two inches down. The zincs are cut from best rolled zinc. There is a simple rheostat attachment for regulating the current for lighting instruments. There are no loose parts, and the battery forms a neat box; and doctors, dentists, and others, will find it a very useful and cheap source of electrical energy.

MESSRS. CUTTRISS AND CO.—We have received from Messrs. Cuttriss and Co. their new catalogue of dynamos, motors, and electrical appliances. Attention is called to the fact that the firm have recently taken much larger premises at Elmwood Electrical Works, Leeds. Illustrated particulars are given of a students' dynamo, manufactured for lecturing purposes, of which Messrs. Cuttriss have made a large number; of the Eclipse dynamo, of the Ring dynamo and motor; of the Alliance dynamos and motors; and of the Dental motor, designed to meet the requirements of the dental profession. An illustration is also given of a cheap motor and ventilating fan manufactured by Messrs. Cuttriss, and of a low-resistance six-cell battery, made in two sizes, one of three pints and one of ten pints capacity. The catalogue closes with a description of the Cuttriss calculating disc, described in *The Electrician* of June 6th, p. 109.

THE AUTOMATIC ELECTRIC RAILWAY COMPANY (LIMITED).—The liquidator of this Company invites offers for the various patents belonging to the Company for the United Kingdom and the Isle of Man. The advertisement states that the inventions have been tested on the Pennsylvania Railway, the New York Central Railway, and the Dortmund Gronau Enschede Railway, with satisfactory results. The liquidator, from whom all further particulars can be obtained, is Mr. J. Harvey Evans, 11, Rumbold street, Liverpool.

ROYAL MILITARY TOURNAMENT.—A very successful installation of the electric light has been put down at the Agricultural Hall, by the Acme Electric Works, from power supplied by Griffin gas engines.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.

PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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FLY CYCLE COMPANY (LIMITED) (IN VOLUNTARY LIQUIDATION).—We have received a note from the liquidator of this Company, Mr. F. G. Emms, of 4, Bethel-street, Norwich, showing the liabilities of the firm to be £3,783. 12s. 7d., against assets estimated to produce £2,728, leaving a deficiency of £1,055. 12s. 7d.

COMPANIES' MEETINGS & REPORTS.

West African Telegraph Company (Limited).

Report of the Directors to the fifth ordinary general meeting, to be held at Winchester House, Old Broad Street, London, E.C., on July 3rd, 1890, at twelve noon :—

The Directors submit the accounts and balance-sheet of the Company for the 12 months ended December 31, 1889.

The Company's revenue for that period amounted to £64,661. 1s. 1d., against which £21,155. 9s. 8d. is charged for ordinary expenses, £1,780. 3s.1d. for hire of cable-repairing ships, and £509. 16s. 2d. for income-tax, leaving a balance of £40,465. 12s. 2d. which, with £4,878. 4s. 8d. brought forward from the preceding year, makes a total of £45,343. 16s. 10d. From this amount is deducted £17,643. 15s. 10d., being for interest on debentures £14,477. 2s. 6d. and for sinking fund £3,166. 13s. 4d., leaving a balance of £27,700. 1s., out of which the Directors have placed £16,145s. 11s. to a general reserve fund.

The Shareholders have received for the six months ending 30th June, 1889, an interim payment amounting to 3s. 6d. per share, and the Directors now recommend a dividend of 6s. 6d. per share, making up 5 per cent. free of income-tax for the year ended 31st December, 1889, which, with the appropriation to the general reserve fund of £16,145. 11s., will absorb the balance standing to the credit of the revenue account.

The Directors have, in addition to the amount of £16,145. 11s., taken from this year's revenue account, placed the balance of £3,074. 2s. 5d., which was standing on the repairs and renewals account, to the general reserve fund. With the interest received during the year from investments, £493. 4s. 7d., this fund now amounts to £19,712. 18s.

The cable between Bonny and Prince's Island (Principé), referred to in the last report, appears as an addition to the capital expenditure during the year. The expenditure on capital account has been increased by £24,771. 7s. 9d. to £508,900. 16s. 5d.

The traffic under the friendly arrangement between the companies whose systems virtually surround the African coast has grown much to the advantage of this Company. The working of these lines as an alternative route has given not only security to the telegraphic system on both the East and West coasts of Africa, but has also largely benefited the revenue of this Company.

The cables of the Company continue in good working order.

The Directors who retire by rotation are Sir John Pender and Robert Kaye Gray, Esq., who, being eligible, offer themselves for re-election.

Mr. James Pender having resigned his seat at the Board the Board have nominated Mr. John Denison Pender Director in his stead. The meeting will be asked to confirm the appointment.

The auditors, Messrs. Deloitte, Dever, Griffiths and Co., offer themselves for re-election.

CITY NOTES, &c.

AFRICAN DIRECT TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons of the Company's Four per Cent. Mortgage Debentures due July 1st next will be paid on and after that date at the Alliance Bank, Bartholomew-lane, London, E.C. The coupons must be left at the bank three clear days for examination. Warrants for the payment of interest on the registered debentures will be sent out on the 30th inst. The debenture register will be closed from the 27th to the 30th inst., both days inclusive.

ANGLO-PORTUGUESE TELEPHONE COMPANY (LIMITED).—Notice is given that Coupon No. 5 of the Six per Cent. Debentures of this Company will be paid, less income-tax, by the Alliance Bank, Bartholomew-lane, on and after July 1st.

BEALE'S (LIMITED).—A Company under this style and title has been incorporated, with a capital of £75,000, in shares of £1 each. The Company is established to carry on the following businesses :—Public caterers, restaurateurs, bakers, confectioners, retail cake and biscuit manufacturers, general provision dealers, licensed victuallers, and electric light and power contractors. We recently announced the formation of a Laundry and Electric Light Company. Whatever may be said against the electric light, it cannot be said that it does not lend itself to commercial combination.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—Notice is given that the coupons on this Company's second issue of Five per Cent. Debentures, due 30th inst., will be paid on and after that date, at the Alliance Bank, Bartholomew-lane, London, E.C. Coupons must be left at the bank three clear days for examination. The receipts of this Company for the week ended June 20th, amounted to £4,098.

COLUMN PRINTING TELEGRAPH INSTRUMENTS.—During the past week advertisements have appeared in some of the financial papers with reference to the instruments recently advertised by the Column Printing Telegraph Company, in the course of which a challenge has been thrown out to the Exchange Telegraph Company to submit their instruments to some kind of promiscuous test. To this the latter Company reply that the challenge in no way disconcerts them, the concluding paragraph of their rejoinder being as follows : "We have said what we consider necessary on the subject of the Column Printing Telegraph Company's prospectus, and await the result. We would state that we have said nothing on the subject of the Column Printing Telegraph Company's prospectus but what we are prepared to substantiate ; and it is not likely, with the threatened litigation, that we should accept a trial of instruments where we may yet have to deal with a case of patent infringement."

LAING, WHARTON, AND DOWN CONSTRUCTION SYNDICATE.—The Directors of this syndicate have decided to recommend to the shareholders, at a meeting to be held on July 18th next, the declaration of a dividend at the rate of 5 per cent. per annum for the period ending March 31st last. The balance sheet of the Company shows a profit at a rate of nearly 9 per cent. per annum, out of which a considerable sum will be carried to reserve.

MANITOBA ELECTRIC AND GAS LIGHT COMPANY.—Messrs. Robert A. McLean and Co., 1, Queen Victoria-street, London, E.C., notify that the half-yearly interest on the First Mortgage Bonds will be paid on July 1st. Coupons must be left three clear days for examination.

THE RECOVERY OF METALS BY ELECTRICITY.—We understand that a project will shortly be placed before the public for subscription for the electrical recovery of pure tin from scrap. We have seen the reports of experts, which are of the most encouraging character ; and with the very considerable and growing demand for this metal no difficulty should be experienced in successfully launching the Company.

STOCK EXCHANGE.—The Committee have appointed Tuesday, July 1st, a special settling day in the Notting Hill Electric Lighting Company (Limited)—ordinary shares, Nos. 142 to 6,459 ; and have ordered the under-mentioned security to be quoted in the official list : Western and Brazilian Telegraph Company (Limited)--further issue of 419 shares, Nos. 91,559 to 92,047. Application has been made to the Committee to appoint a special settling day in the Commercial Cable Company, £2,716,000 capital stock.

SUBMARINE CABLES FOR THE FRENCH COLONIES.—The Paris correspondent of *The Statist* announces that there will shortly be formed a new Submarine Telegraph Company, whose business will be to lay cables connecting the French Colonies with other countries. The prospectus was issued on Wednesday last for 11,000 shares of 500fr. each, at par, under the auspices of the Comptoir National, Société Générale des Téléphones, Banque d'Escompte, &c. The Company obtains from the French Colonies an annual subsidy of 260,000fr. and from the Dutch Colony of Curaçao the guaranteed annual minimum receipt of 95,000fr. The Paris Telephone Company guarantees to the shareholders of the new Company 5 per cent. annual interest.

TELEPHONE COMPANY OF AUSTRIA (LIMITED).—Notice is given that Coupon No. 11 of the Five per Cent. Debentures of this Company will be paid, less income-tax, by Messrs. Martin and Co., 68, Lombard-street, on and after July 1st.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended June 20, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,154.

THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

VULCANISED FIBRE,

PATENTED.

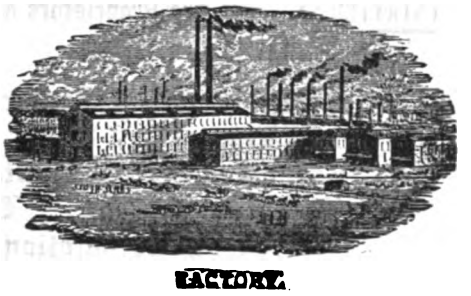
This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50th. to 1in.


FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 18.		Price Wednesday, June 25.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending June 25.	
										Highest.	Lowest.
£			**TELEGRAPHS.**					£ s. d.			
1,381,330	Stock	12/6	Anglo-American	50½	51½	50	51	5 7 10	Jan., Apr., July, Oct.	50	..
2,809,310	Stock	25/0	Do. Preferred	87	88	86	87	5 14 11	" " "	87	86½
2,809,310	Stock	..	Do. Deferred	15	15½	14¾	15½	..		15	14¾
25,000	£100	4%	African Direct, 4 per Cent. Debentures	99	102	99	102	3 18 5	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine	11¾	12¼	11¾	12¼	6 2 5	Mar., June, Oct., Dec.	12¾	12⅞
69,200	100	5%	Do. 5 per Cent. Bonds	101	103	101	104	4 17 1	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	106	109	106	109	4 11 9	June and December	..	..
..	$100	..	Commercial Cables	104½	104¾	104½	104¾	..		..	..
16,000	£10	9/0	Cuba Submarine	11¾	12¼	12	12½	7 4 0	February and August	12½	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3¾	4¼	3¾	4¼	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October..	9⅝	9½
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 14 11	Jan., Apr., July, Oct.	10⅝	..
400,000	10	2/6	Eastern	13⅝	14⅛	14	14½	4 11 3	" "	14⅝	13⅝
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15⅞	15½
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108¼	107½
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	109	..
250,000	10	6/6	Eastern Extension	14⅛	14⅜	14½	14⅝	4 16 7	Jan., Apr., July, Oct.	14⅝	14⅞
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101	103	101	103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 per Cent. (Austin. Gov. Sub.) Debs. 1900	103	106	104	107	4 13 8	January and July ..	..	..
145,900	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	" "	..	..
180,227	10	2/0	Globe Telegraph and Trust	8⅞	9⅛	8⅞	9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅝	15⅛	15	15½	3 18 8	" "	15⅜	15⅛
150,000	10	5/0	Great Northern	15⅝	16⅛	15⅝	16⅛	4 12 4	Jan., July, and April	16½	16
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	102	105	102	105	4 15 3	January and July ..	104½	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	37	39	37	39	6 8 2	April and October ..	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	" "	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞	8⅛	7⅞	8⅛	6 1 3	April and October..	8⅛	..
3,381	£100 Cert.	..	Submarine Cables Trust	112	116	112	116	..	" "	116	115⅛
15,609	£10	5%	West African	9⅛	10⅛	9⅛	10⅛	4 10 11		..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	100⅛	100
30,000	10	2/0	West Coast of America	6½	7	6½	7	8 11 5	January and July ..	..	..
150,000	100	8%	Do. Debentures 8%	111	116	111	116	6 17 11	June and December	113⅛	..
88,321	10	Nil.	West India and Panama	2⅜	2⅝	2⅜	2⅝	..		2⅝	..
34,563	10	6/0	Do. 1st Preference 6%	11	11½	11	11½	5 4 4	April and October..	11⅜	11⅛
4,689	10	27/6	Do. 6 p. c. 2nd Pref.	12⅛	13⅛	12½	13⅛	..		..	..
64,572	15	6/0	Western and Brazilian	10	10⅛	10	10⅛	5 14 4	May and November	10⅛	..
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	6⅞	6⅛	7	..	..	6⅞	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3⅛	4	3⅛	4	..	..	3⅛	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	104½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5½	Consolidated Telephone Const. and Maintenance..	⅛	¼	⅛	¼	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼	⅜	¼	⅜	4 8 3	Yearly	..	..
386,875	5	3/0	National	5½	6	5⅛	5⅝	..	June and December	5⅛	5⅛
49,525	5	1/4½	Do. New	5⅛	6	5	5⅛	..		5⅛	5⅛
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference..	12⅛	13	12⅛	13	4 12 4	June and December	..	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference..	10⅛	10⅝	10⅛	10⅝	..	" "	..	..
209,750	1	..	South of England, Ordinary	⅛	..	⅛	..	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3⅛	3⅜	3	3⅛	..	..	..	..
55,000	5	2/0	United River Plate	4⅜	5	4⅛	5	..	January and July ..	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..	..	..	..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅛	2⅜	2⅛	2⅜	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5⅛	5⅜	5⅛	5⅜	..	..	..	..
42,853	5	..	Westminster Electric Supply	1⅛	2⅛	1⅜	2⅛	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅜	2⅝	2⅛	2⅜	..	..	2⅜	2⅛
63,416	2	1/2	Do. Preference	1⅜	2⅛	1⅜	2	..	..	..	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5⅛	5⅜	5⅛	5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
409,000	10	..	Electric Construction	9⅜	10⅛	9⅜	10⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5	5⅛	5⅛	6⅛	..	..	6	5⅛
20,000	5	..	Fowler-Waring Cables	2⅛	2⅜	2⅛	2⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works..	19	20	19	20	5 0 0	February & August	..	..
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5⅛	5⅜	5⅛	5⅜	3 13 0	..	5⅛	..
37,350	12	36/0	Telegraph Construction and Maintenance	44	46	44	46	5 3 11	March and July.....	45⅛	44⅛
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	101	104	101	104	4 16 2	..	..	..

JABLOCHKOFF'S DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED

(STATTER'S) **Are Proprietors of the above Patent, and Warn the Public against Infringement.** (UNITED).

The following are Licensees:—

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 633.—Vol. XXV. FRIDAY, JULY 4, 1890. Price Fourpence.

NOTES.

There were three men who led the way in electric lighting by glow lamps. One of these was Mr. Lane Fox, nor was he the least original or persevering or scientific of the three. But we regret, and the regret will, we are sure, be shared by all fair-minded people, that he has received the least reward for his work. We understand that one of the transfers alluded to by the Chairman at the recent meeting was a sale of the patents by the inventor, but we have not endeavoured to push our investigations into this matter. That very great credit is due to Mr. Lane Fox cannot for a moment be denied; but that royalties are also due is, unfortunately, a matter of uncertainty, that is to say, a matter of law.

The meeting which was held on Tuesday was too small to be of any value as a representation of the trade, but was important as the occasion of a clear statement by the Lane Fox Electrical Company of their claims, and, to a certain extent, of their attitude. If the royalty which they claim from the Kensington and Knightsbridge Company really only amounts to £300 a year for two years, the matter is hardly worth discussing, and certainly not worth fighting about. The exact sum concerns no one but the negotiating parties; but if the undertakers find it to be a burden, they would be put to but little inconvenience if they disconnected their batteries and kept up steam, running their engines at times on a very light or on a very heavy load, and until the patents expire. The cost of coal and attendance would be easy for them to calculate. Then arises the question of retrospective royalties; and here, as a matter of common fairness, the Lane Fox Company must, before they ask for royalties, explain clearly, and, if necessary, subject to discussion, why so few attempts have been made to uphold the patent. We understand that the "Pavilion" case and the "Athenæum Club" case, were both founded on this patent, but we are speaking from hearsay, as the history of electric lighting has yet to be written; and a very interesting history it will be. At all events, no case was ever won on this patent, and the argument has been used more than once, that the Anglo-American Brush Company can hardly be credited with purely philanthropic motives for the way in which, while holding this patent, they have allowed the use of accumulators for lighting purposes without a murmur.

It is somewhat difficult to account for the summary rejection last week of the London Overhead Wires Bill. If the metropolis is to be saved from a modified repetition of the recent mishaps in New York, the overhead wire question should be placed on a satisfactory basis; and reasonable regulation by the County Council would appear to be the best solution. The Bill in question provided such reasonable regulation; but the fact that it contained a clause giving powers of compulsorily entering upon private property for the purpose of putting up wires and inspecting them proved sufficient to ensure its rejection, although endeavours were made to guard the rights of householders. One member, not acquainted apparently with the model form of Provisional Order, said the question was not one of erecting telephone wires but electric light wires. But, as Sir J. Bailey pointed out, it is the derelict wires which are most in need of supervision, the "live" overhead wires in the Metropolis, whether for electric lighting or telephonic purposes, being probably as safe as any in existence. We trust another attempt will be made next Session to devise a Bill which will attain the objects of the one just thrown out, without arousing such strenuous opposition on the part of owners of property.

The numerous questions which have been asked in the House of Commons with regard to the transfer clauses which the Board of Trade has thought fit to insert in the Provisional Orders granted to Local Authorities show that this new departure is not viewed with unqualified satisfaction by members of the Legislature. Up to the present members have only received the stereotyped reply given to the recent deputation of electric lighting companies. The President of the Board of Trade has "confidence in the discretion of the Local Authorities." However well this confidence in the discretion of Local Authorities may be justified, it would nevertheless be satisfactory to learn in what way electricity differs so greatly from gas that the introduction of the foreign principle of "concessions" has been rendered necessary.

We publish this week an interesting note on the magnetic circuit by Mr. Carter, who has also worked out a useful table of constants, by aid of which calculations connected with the design of dynamos may be shortened. The analogy between electricity and magnetism is complete in every respect when properly worked out in the way Mr. Oliver Heaviside has shown; and a Paper setting forth this analogy in simple language would serve a very useful purpose. Mr. Carter has, however, not chosen the right analogue of electric resistance. The analogue of lines of induction produced by magnetic force is really the charge of a condenser produced by electro-

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motive force. The electric resistance determines the waste of energy caused by the passage of a current, but the quantity often called magnetic resistance is not in any way associated with waste by heating, and is really analogous with capacity. No substance has yet been found to conduct a magnetic current in the way a piece of copper conducts an electric current, or the true analogue of electric resistance would be well understood. It is true, as Mr. CARTER says, that unnecessary complication arises in calculations from the mixture of metrical and English units; and it is, therefore, to be regretted that in working out the table of numbers the foot has been taken as the unit of length and the square inch as the unit of area.

ON the 1st of July, 1894, the existing agreement between the Glasgow Tramway and Omnibus Co. and the Glasgow Corporation, for the working of the municipal tramway system of that town, will expire; and the question of what is then to be done has already been raised. Negotiations have been entered into with present lessees, but so far it has been impossible to arrange mutually satisfactory terms. The Corporation have therefore now to consider whether they will get a special Act and work the tramways themselves, lease them to another Company, or enter into further negotiations with the present one. Many members of the Corporation, we believe, advocate the working of the lines by the municipal authorities themselves, and the adoption of electricity.

THE Glasgow Corporation, it will be remembered, is at the present moment promoting an electric lighting Provisional Order, and proposes to expend a large sum of money in establishing an electricity supply system. Should the municipality therefore decide to obtain a special Act we trust there will be a clause permitting the use of electric traction, which it will be able to adopt under especially favourable circumstances. Inquiries, we are told, have been already set on foot with a view of obtaining reliable information upon the subject of electric traction. We would suggest to the Corporation that instead of confining these inquiries to what is being done in this country, and remaining content to witness experimental runs of experimental cars, that they should engage the services of a competent electrical engineer, and should instruct him to place before them reliable statistics relating to the total mileage, cost of working, and different systems of the electrical street railways of the United States. A Corporation owning tramway lines 30 miles in extent, and upon which it has expended about £350,000, would do well to be in possession of all the facts relating to electric traction before deciding as to its adoption or rejection.

THE prospectus of the International Okonite Company, which was issued early this week, has been so drawn up as to avoid all technical criticism. Not the smallest hint is given as to what okonite is; the nature and extent of the sources from which it is obtained; the price, which we understand is about three times that of gutta percha; or the materials with which it competes. Neither the result of laboratory tests, nor the testimonials of those who have used it in practice, can be taken as a guide to an investor in a manufacturing business of this kind. The main question is, how will it compete with the thoroughly reliable products of the old-established firms of this country?

WE are glad to hear that there is every probability that the £3,000 which is required to enable the Maxim-Weston Company to continue its operations will be subscribed among the shareholders.

OUR readers will be glad to see that we are commencing in the present issue the second series of articles by Dr. FLEMING. These will constitute the second volume of "The Alternate-Current Transformer in Theory and Practice," and will be devoted to the applications of theory to practice, including the subjects of Measurements, the Construction, Design, and Use of Transformers, and their applications in lighting, welding, and other work.

The Halifax-Bermuda Submarine Cable.—The laying of this cable has been completed.

"Electrical Plant."—We are informed that Mr. E. R. Dolby is now editing *Electrical Plant*.

King's College.—The Professorship of Mechanical Engineering at this College will shortly be vacant.

Personal.—Mr. A. E. Mavor has been appointed general manager of the Fowler-Waring Cables Company.

Royal Institution.—The general monthly meeting of this Institution will be held on Monday, July 7th, at 5 p.m.

Electric Lighting Acts Amendment (Scotland) Bill.—This Bill was read a third time in the House of Lords on Tuesday last.

City of London and Southwark Subway Bill.—This Bill was read a third time in the House of Lords on Friday last and passed.

Newry.—The Irish House-to-House Electricity Company has announced its intention of applying for a Provisional Order for Newry in the next Session of Parliament.

Postal Telegraph Revenue.—The receipts from the telegraph service for the quarter ended June 30, 1890, amounted to £555,000, as against £525,000 for the corresponding quarter last year.

Society of Arts.—At the meeting of the Council of this Society on Tuesday last Sir Richard Webster was elected chairman and Sir Frederick Bramwell deputy-chairman for the ensuing year.

Telegraphic Communication with Tory Island.—The steamer Buccaneer left Silvertown on Wednesday to lay the cable connecting Lloyd's signal and telegraph station on Tory Island with the mainland.

Merchant Venturers' School, Bristol.—The posts of Physical and Mathematical and of Chemical and Metallurgical Master at this school are vacant. Further particulars will be found in our advertisement columns.

Personal.—Mr. F. Quicke, works manager to Messrs. Immisch and Co., was installed Worshipful Master of the Chislehurst Lodge of Freemasons, No. 1,531, at Chislehurst, on Saturday last, in the presence of a large number of metropolitan brethren.

Personal.—We are informed that Mr. William Robinson, M.E., Senior Demonstrator of Physics and Electrical Engineering at Finsbury Technical College, was yesterday unanimously appointed Professor of Engineering at University College, Nottingham.

Leeds.—Owing to the gas stokers' strike, the *Yorkshire Post* had to be produced by candle-light, but on Wednesday the electric light was temporarily installed at the offices of that paper. At the *Leeds Mercury* offices the electric light has been in use for some time.

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Coventry.—The Coventry Telephone Exchange was opened on the 24th June last year with 27 subscribers; there are now 90 subscribers. In the first week there were 32 "trunk" calls and 748 local; the record for the last week of June shows 287 "trunk" calls and 2,930 local.

Liverpool Engineering Society.—The first excursion this season of the above society was to Keswick. A visit was made to the works of the Keswick Electric Supply Company. A representative of Messrs. Fawcus and Cowen, the engineers for the scheme, explained the working of the system.

The Electric Light in Holland.—The Communal Council in Amsterdam is now discussing the proposal for granting an exclusive concession for the electric lighting of the city during a term of years. The town authorities of Rotterdam have also introduced a similar Bill into their own Council for the lighting of Rotterdam.

Electrical Trades Section River Excursion.—This excursion will take place to-morrow. The "Viscountess Bury" will leave Windsor at noon, and is expected to reach Henley at about six p.m., and the party will return from Henley by train. It is expected that arrangements will be made with the Great Western Railway for special facilities.

Telegraphic Communication between France and the North African Coast.—M. de Selves has submitted a report to M. Jules Roche, the Minister of Commerce, asking for two new cables to be laid connecting Marseilles with Oran and Tunis. Money is also asked to improve telegraphic communication with Corsica. At present there are only three Franco-Algerian cables belonging to the Government, two of which are in a very bad condition.

Rain as a Lightning Protector.—In a Paper recently read before the Royal Meteorological Society, Captain J. P. Maclear, R.N., stated that he examined a number of trees near Cranleigh which had been struck by lightning during the thunderstorms of June 6, 7, 1889, and found that those which were struck before the rain fell were shattered, while those which were struck after the rain commenced were simply scored, with the bark blown off.

Express Messengers for London.—A conversazione will take place on Saturday, 12th of July, at the Royal Institute of Painters in Water Colours, at which the Duke of Abercorn will give a short description of the "Messenger Call System" and its advantages. Captain Davies, of the Exchange Telegraph Company, who was the first to introduce the "call system" into England, has kindly arranged to fix up an installation exhibiting the system in actual operation.

Aberdeen.—The Gas Committee of the Town Council met on Monday to consider the Provisional Order as altered by the Board of Trade. The charge for providing electricity for lighting purposes is fixed at 13s. 4d. per quarter for 20 units, every additional unit being charged at the rate of 8d. The Committee resolved to make a representation that Aberdeen, in consideration of its distance from the coal fields, and the wide area to be supplied, should be empowered to exact a charge of 9d. a unit.

Telephonic Extensions in Hampshire.—On Monday the new trunk line between Southampton, Bournemouth, Poole and Christchurch was formally opened for traffic. This line practically completes the work the Western Counties Telephone Company intend to carry out in South Hants for the present. The following is the number of subscribers in each of the towns now in telephonic communication:—Portsmouth, 220; Southampton, 125; Winchester, 10; Bournemouth, 250; Boscombe, 20; Poole, 18; and Christchurch, 12.

The Double-Carbon Lamp Litigation.—The Circuit Court of the United States for the northern district of Illinois has granted an injunction restraining the Sperry Electric Company, until the final hearing of the action, "Gresham *v.* Blodgett," from making, selling, offering for sale, or using any double-carbon lamps in which two or more pairs of carbons are independently adjusted and regulated, and are burned successively, as set forth and claimed in the first claim of letters patent No. 219,208, granted to Charles F. Brush, September 2, 1879.

The Copper used by Electrical Companies.—The following are a few figures with regard to the amount of copper used by some electrical companies in the United States. The Boston Edison Lighting Company has about 530 tons of copper wire buried under the streets. The New England Telephone and Telegraph Company have in underground service nearly 260 tons of copper. The American Telephone and Telegraph Company use about 900 tons. The Thomson-Houston Electric Company have built electric railways taking over 700 tons of copper.

Electric v. Steam Locomotion.—In a Paper by Mr. O. T. Crosby, read at the Boston meeting of the American Institute of Electrical Engineers, he comes to the conclusion (1) that a low-speed armature placed on the car axle would place the electric motor in the lead at all service speeds; (2) for speeds above 70 miles per hour a geared electric motor with 20 per cent. loss would prove more economical than the steam locomotive save in cases of very infrequent service on long lines; (3) at speeds of 100 miles per hour and upward neither steam at 90 per cent. nor electric apparatus at 60 per cent. is commercially practicable.

Southend.—At a special meeting of the Southend Local Board, the contract with Messrs. Crompton and Co. for doing the temporary and permanent work in connection with the electric lighting and tramway on the new pier was agreed to. The contract provides that the temporary work is to be finished by August 1st, under a penalty of £10 a day. The permanent works are to be finished by May 1, 1891. Messrs. Crompton are to run and work the tramway this season and one month next season; and they undertake to pay £5 a day for every day upon which the tramway ceases to work for two hours.

Thunderstorms.—On Friday last a violent thunderstorm visited Sunderland. The telephone apparatus at the Central Police Station and two houses were struck. During a thunderstorm at Skendleby, near Spilsby, on Saturday, a man in charge of a mowing machine was struck by lightning and killed, together with the horse attached to the machine. At Teignmouth two boys were struck by lightning. At Warrington a house was struck. In the neighbourhood of Wooler, on Thursday, a flock of 33 sheep, which had sought shelter in an uninhabited house, were all killed by a flash of lightning which struck the house.

The Edinburgh Meeting of the Institution of Electrical Engineers.—We are informed that both the London and North-Western and the Midland Railway Companies have consented to issue to any members of the Institution who may be proceeding to the Edinburgh meeting, return tickets of any class, available for eight days, at the same reduced price as has been agreed to by the Great Northern Company, viz., a single fare and a quarter. The tickets will be issued from any of the stations of these companies' lines on production of a note signed by the Secretary. A circular respecting these notes, accompanied by a programme of the proceedings, will be issued in a few days to all who may have intimated their intention to attend the meeting. Over 100 names have already been sent in.

The Lighting of the City.—At the last meeting of the Commissioners of Sewers the Solicitor stated that he had received what purported to be an agreement from the solicitor of the Laing, Wharton, and Down Syndicate on the part of the alien Company at Boston—the Thomson-Houston Company—as to the question of a guarantee. As there was no time now to get the formal agreement exchanged between the alien Company at Boston, he thought it would be unwise to throw up the Provisional Order on the technical ground that the guarantee had not been sent. A lengthy discussion ensued, and an amendment was moved that no consent should be given to a Provisional Order without the guarantee. Voting then took place upon the amendment, with the result that it was lost by three votes.

The Paris Central Stations.—The *Bulletin International de l'Electricité* estimates that three-quarters of the total available engine-power at the Paris central stations lies idle for twelve hours out of the twenty-four. It suggests as a means of

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employing these engines that industries requiring power should be established adjoining the central stations, and the spare power utilised in this way during the hours of light load.—The Conseil d'Hygiène et de Salubrité de la Seine has decided to place electric lighting stations employing more than 100 indicated horse-power in the class of "dangerous establishments." In the report of M. Michel Lévy upon this subject, it is stated that the horse-power of the 20 central stations of Paris now amounts to 10,000, or one-sixth of the total motive power used in the Department of the Seine.

The Rotation of the Plane of Polarisation as a Measure of Current.—In 1851 Wiedemann discovered that if a tube containing bisulphide of carbon is surrounded with a wire carrying a current, the rotation of the plane of polarisation is exactly proportional to the strength of the current. Starting from this point M. d'Arsonval has devised a very simple arrangement for measuring currents and testing the accuracy of ammeters. In the apparatus recently shown to the Société de Physique, a coil of wire was wrapped round an ordinary saccharimeter tube containing pure water or bisulphide of carbon. The E.M.F. of a single Leclanché cell will cause a rotation of 1deg. The apparatus can be made as sensitive as one pleases, since for a given current the sensilibity depends simply upon the number of convolutions of the coil.

The Mechanical Equivalent of Light.—According to Dr. O Tumlirz a surface of one square centimetre placed vertically at a distance of 1 metre from an amyl-acetate lamp, so that it is normal to the rays, receives in each second a quantity of light, the energy of which is equivalent to a heat energy of

$$361 \times 10^{-9} \text{ calories,}$$

or to an electrical energy of

$$(1{\cdot}226 \text{ milliamperes})^2 \times 1\Omega.$$

Taking this in conjunction with the statement of S. P. Langley that 1 square cm. of the earth's surface, under vertical incidence of the sun's rays, receives in a minute 2·84 calories, it will be seen that the sun's light can be replaced by 1,020 quadrillion units of light, or 820 quadrillion normal German candles.

Accumulators with Porous Partitions.—In connection with M. Regnier's latest form of storage cell, referred to by our Paris correspondent in our issue of June 20th, M. Chatiliez, manager of the Verdun water power electrical station, writes to *L'Electricien* to say that he has met with considerable success by employing ordinary porous partitions between the battery plates. These partitions are fluted to admit of the introduction of the electrolyte and pierced with holes to allow the liquid to circulate, and to diminish the internal resistance. The end plates rest against india-rubber washers. M. Chatiliez states that a series of experiments with these plates have shown that the grids may be made lighter and the perforations larger than usual without detriment. The internal resistance of the cells may be kept within moderate limits by slightly increasing the density of the solution.

The Government and the Telephones.—The Duke of Marlborough intends to ask the House of Lords to agree to a resolution declaring it advisable that telephone licences shall be granted to responsible parties willing to undertake the business of forming new telephone companies on the expiry of the patents owned by the National Telephone Company.—At its last meeting the Edinburgh Chamber of Commerce considered the announcement of the Postmaster-General with regard to the taking over of the telephone system by the Government. A strong feeling was expressed that in the public interest the telephone system should be acquired; and it was agreed to make a representation to Mr. Raikes, and to the members for the City, with a view to the Government either altering its decision or making such a statement on the question as would satisfy the public that the course proposed by the Government was a desirable one.

Notes on Thunderstorms.—Mr. R. H. Scott has contributed a note on thunderstorms to "Longman's Magazine" for June, showing various peculiarities in their behaviour in this country and abroad. These storms are generally divided into two groups: (1) heat thunderstorms (the summer type), and (2) cyclonic thunderstorms, which occur principally in autumn and winter. The frequency of the storms is much greater in low latitudes than in high, and their energy is materially moderated by the dampness of the climate; hence our own comparative immunity from them. Certain districts also appear more liable to storms than others; the damage by hail, which frequently accompanies electrical discharges, appears to be greater in Huntingdonshire and neighbouring counties than in other parts of England. From an extensive inquiry by the Berlin Statistical Office, published in 1866, it appears that houses with thatched roofs are struck by lightning much more frequently than slated houses, while houses in towns are less frequently affected than those in the country.

Italian Telegraph Statistics.—The Italian telegraph system was increased during 1889 by 1,474 kilometres of lines, and 9,704 kilometres of conductors, the total at the close of the year being 35,322 kilometres of lines and 128,209 kilometres of conductors. Of the lines 15,225 kilometres are along railways, and 20,097 kilometres along ordinary roads; of the conductors 91,671 kilometres are along railways, and 36,538 kilometres along roads. During 1888-1889, 5,322 interruptions occurred, 2,501 of these being on railway lines and 2,821 on roads; 81 cases were due to damage to the posts, 538 to broken insulators, 724 to breaking of wires; contacts and short circuits were responsible for 3,571, and lightning for 408. During 1888 and the first half of 1889 10 new cables were laid. The total length of Italian cables at the end of 1889 was 3,988 kilometres, of which only 11 cables (146·140 kilometres) belonged to the State; the remainder belonging to the Eastern Telegraph Company, Pirelli and Co., and other private companies.

An Improved Connection for Carbon Battery Plates.—A useful little improvement in the way of connecting the carbon plates of batteries has been devised by Mr. Dopping-Hepenstal, R.E. A small hole is drilled through the carbon plate about ¼in. from the upper edge. A piece of platinum wire, 24 or 22 S.W.G., is next snipped off obliquely, so as to form a chamfered end, and the last quarter of an inch or so of the piece is bent back upon itself, and pinched tight. The piece is then passed through the hole in the carbon plate, and pressed in hand tight, until arrested by the swell of the loop. A length of two to three inches will usually be found convenient. The plate may be partially or totally submerged in the exciting fluid. It does not matter whether the actual junction between carbon and platinum is above the level of the exciting liquid in the cell or below it, the platinum being, for all practical purposes, incorrodible. Thus a Leclanché cell can be sealed up, the carbon plate being entirely within the cell, and connected to the outside by a single platinum wire passing through the seal.

The Press Rates to South America.—Press messages are now transmitted from London by the cables of the Brazilian Submarine and Western and Brazilian Companies at the following reduced rates:—

	Per word. s.	d.
To Madeira	0	8
,, St. Vincent	1	6
,, Pernambuco	3	1
,, Para, ,, Maranham, ,, Ceara, ,, Bahia, ,, Rio de Janeiro	3	6
,, Santos, ,, Santa Catarina, ,, Rio Grande do Sol	3	11
,, Monte Video	4	1
,, Buenos Ayres	3	7

These telegrams are subject to the usual conditions governing press messages.

Cardiff.—Mr. E. Garcke, writing to the *Cardiff News*, says that his Company has for twelve months been unable to obtain an interview with the Corporation or their Lighting Committee. They seek no monopoly. Their intention was to undertake the lighting of the whole area within the jurisdiction of the Corporation. Mr. Garcke points out that the ratepayers can obtain the best light at the cheapest price by fair

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competition between gas and electric light companies. It is true that the Brush Electrical Engineering Company can continue business as hitherto, but they cannot extend their operations by underground mains, except by the consent of the local authorities to their application for a Provisional Order. A memorial signed by 45 ratepayers supports a conference. It appears to us that the Brush Company have been very hardly dealt with in this matter. The Corporation, who desire to take every advantage of the new regulations, appear to be rather uncertain of their position, in persisting in declining even an interview with a representative of the contractors who, for the last seven or eight years, have been supplying Cardiff with electric light.

The Transfer of Provisional Orders.—In the House of Commons last week Mr. Beaufoy asked the President of the Board of Trade whether, as it was contrary to practice to allow Local Authorities by one and the same Act or Provisional Order to establish gas undertakings with power to transfer them, he would state the reasons which had led him to depart from this practice in the case of electric lighting orders which the Board had recently granted to Local Authorities. Sir M. Hicks-Beach said he had nothing to add to the replies he had already given with reference to this matter. He had confidence in the discretion of the Local Authorities, and, with the safeguards contained in the clause referred to, he did not think the interests of the public could suffer. In reply to a further question from Mr. Beaufoy, Sir M. Hicks-Beach said Section 5 of the Electric Lighting Act, 1882, required that rules made by the Board of Trade under that Act should be laid before Parliament, but there was no similar provision in respect to the model form of Provisional Order. The orders, as granted by the Board of Trade, were submitted to Parliament for confirmation, and had no force until so confirmed.

Telegraphists and Overtime.—In the House of Commons, on Tuesday evening, Mr. Lafone asked the Postmaster-General whether there was any truth in the rumour that the telegraphists had refused to work overtime? Mr. Raikes stated in reply that at the Central Telegraph Office it was impossible to carry on the work without overtime. Every effort was made, however, to restrict the overtime, and additions were made to the staff from time to time as the number of messages increased or additional wires were brought into operation. Less than a year ago authority was given to increase the number of telegraphists by 100, and no time was lost in training the new hands. The question of a further increase of the force was now under examination. The necessity for overtime was, he was sure, appreciated by the general body of the telegraphists, and he did not entertain any apprehension that these officers had it in contemplation to refuse to perform duties which were required in the interests of the public. If overtime were entirely abolished there would be a grievance on the part of a large proportion of the staff by whom the payment for the overtime was welcomed as an additional source of income.

The Dynamo Plant at the Chicago Telegraph Office.—After an experience of two years at the New York office with current supplied from dynamos instead of batteries, the Postal Telegraph Company, says the *Western Electrician*, recently decided to adopt this system in Pittsburg and Chicago. On May 1 a plant of generators was started in the latter city in the basement of the Phœnix building. The dynamos took the place of 9,000 cells. The installation consists of sixteen shunt-wound generators, and two 10-horse power 220 volt motors. The motors are fed from two separate and distinct leads from the Edison system. Although there are sixteen generators in all, one set of eight machines is all that is required for the regular service. The other set of eight machines is kept as a reserve. One dynamo in each set furnishes current to all the locals, loops, city wires, and call-box circuits. The seven others of a set range from 70 to 350 volts for main line circuits. All the leads from the dynamos connect with the instruments and line, through resistance coils. These coils are proportioned for the service required on the lines, and are introduced as a precaution against damage from the sudden short-circuiting or grounding of a line. These resistances are figured at about two ohms to one volt.

Electrolysis of the Muscles.—In a recent number of the *Bulletin de la Société Belge d'Electriciens*, Dr. G. Weiss contributes a brief account of some interesting electro-medical investigations undertaken by him. That electrolytic effects take place at the electrodes where an electric current enters and leaves the human body is, says Dr. Weiss, universally admitted; but is the electrolytic action confined to these points? Dr. Weiss then points out how, when intermittent currents of the same size are sent along the gastronemian muscles of a frog's leg, the contractions rapidly cease, and no amount of rest restores the muscles to their primitive condition. On the other hand, the duration of an alternating current does not perceptibly affect the contractions. This phenomenon points, therefore, to electrolysis of the muscle along the entire path of the current. Dr. Weiss then tested this theory as follows. He took two vessels containing a 1 per cent. solution of chloride of sodium, connected them by a syphon filled with the same liquid, and passed a given current from vessel to vessel, using platinum electrodes. The experiment was then repeated with the two hind legs of a frog as connecting piece. The E.M.F. of polarisation was considerably greater in the latter case than in the former. Dr. Weiss is of opinion that an electric current traversing a muscle gives rise along the whole length of its path to chemical decompositions, and that the products of these give rise in their turn to powerful secondary actions upon the substance of the muscles, which are rapidly attacked and destroyed. Microscopic examinations showed that the entire structure of a muscle was gradually altered by the passage of a current. Dr. Weiss then poured a strongly saline solution of gelatine, coloured with well neutralised-turnsol, into a U tube, and when the gelatine had solidified he poured in water coloured in a similar manner. The turnsol not only changed colour at the platinum electrodes but also at surface, separating the gelatine and the water. With albuminous water the albumen was coagulated at the positive and completely dissolved at the negative surface of separation.

Accumulators at the Berlin Telegraph Office.—In a Paper recently read before the Elektrotechnischer Verein, Herr Strecker, chief engineer to the German Imperial Telegraph Department, gave a brief account of the accumulators, which had been installed in Berlin in connection with the telegraph service. In October last a battery of 25 Tudor accumulators, having a capacity of 25 ampere hours, was installed at the Berlin telegraph offices. The cells are charged with a current of 7 amperes by a shunt-wound Siemens machine, driven by a 5 horse-power Otto engine. The current is conveyed to the central office, distant 1·7 kilometre, by means of a seven-wire cable, each wire having 5 ohms resistance. Only three wires are at present used, and they convey the current in the following manner: The first, starting from the eighteenth cell of the battery, supplies 36 circuits at 34 volts; the second, starting from the twentieth cell, supplies 12 circuits at 40 volts; the third starts from the last cell of the battery, and supplies 13 circuits at 50 volts, six circuits at 60 volts, and one circuit at 80 volts. In the two last circuits 10 and 30 primary cells respectively are added to the secondary cells. These 68 lines comprise 41 Morse and 27 Hughes circuits. The negative pole of the battery is connected to earth. The average discharge is at the rate of 60 milliamperes, so that the accumulators can supply this from 30 to 40 days, although, as a matter of fact, they are charged every ten days. The charging is effected in the following manner:—The dynamo is switched on to the accumulators through a very high resistance, so that the charging current is at first very small indeed. A wire is taken from the centre of the battery to earth through a voltmeter, and when the E.M.F. rises by about 2 volts, the engineer in charge, by means of a switch, switches out a cell from the telegraph circuits, still leaving it in the charging circuits. The charging current is then increased, and as the E.M.F. rises still further more cells are switched out. The reverse process is gone through on stopping. The difference of potential on the telegraphic circuit during the charging operations is kept so uniform that no complaints have ever been received from the central office. Since the cells were first employed in the beginning of October, 1889, they have worked in an irreproachable manner, and the authorities are so satisfied with them that they now propose to adopt them on a far larger scale

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MAGNETISM IN IRON AND OTHER METALS.*—XXII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 197.*)

§ 87. **Lord Rayleigh's Experiments.**—The inference drawn by Baur as to the value of κ when H is zero depends on the legitimacy of extending the straight line connecting κ and H backward beyond the region of actual experiment to cut the axis of κ. It has been entirely confirmed by the experiments of Lord Rayleigh,† who has examined the action of much feebler magnetic forces, and has found that the proportionality of magnetic induction to magnetic force continues to hold good when the force is excessively reduced.

In his experiments a bar or wire of iron was tested magnetometrically with one end very near the magnetometer, and with a compensating coil adjusted to balance the magnetism which a feeble magnetising current induced in the bar. The specimen under examination being a piece of Swedish iron wire (not annealed), the compensating coil was adjusted so that there was no movement of the magnetometer needle when a magnetising current was made or broken, the strength being such as to give a field of 0·04 C.-G.-S. Then the strength of the current was gradually reduced till the magnetic force fell to about 0·00004, and it was found that the compensation remained perfect. In other words, within these limits the induced magnetism was proportional to the inducing force: κ and μ were constant. "In view of this," says Lord Rayleigh, "neither theory nor observation give us any reason for thinking that the proportionality would fail for still smaller forces." Quite similar results were obtained with other specimens of unannealed iron and of steel. The range through which κ and μ are sensibly constant is much less in annealed than in hard iron. Within this range of force there is no retentiveness; the magnetising process begins like the straining of a solid body with an elastic stage within which there is no "permanent set." When the magnetising force was increased above 0·04 the compensation failed to remain exact, and the deviations followed the parabolic law stated above. The formulas

$$\kappa = 6{\cdot}4 + 5{\cdot}1\,\mathsf{H}$$
$$\mu = 81 + 64\,\mathsf{H}$$

agreed well with the results of experiment for values of H ranging up to 1·2 C.-G.-S. unit. (In comparing these with the formula given in the last paragraph, it must be remembered that they refer to hard iron, the others to annealed iron: the initial susceptibility is less here, and the deviation from the initial value is very much less rapid.) With another specimen of hard-drawn iron wire the initial value of μ was 87.

Lord Rayleigh has also examined the effect of alternately applying and removing a small amount of magnetic force, when the piece is kept more or less strongly magnetised by means of a constant force. So long as the constant force is moderately small, and the mean magnetisation consequently not very strong, the susceptibility with regard to alternate applications and removals of a small part of the force is not materially different from the initial susceptibility of the same piece when unmagnetised. But as the mean magnetisation is raised, the susceptibility with respect to small changes of force becomes reduced. In a piece of hard iron a steady force of 29 C.-G.-S. had the effect of reducing the susceptibility with respect to small alternations by about 40 per cent. of its original value; and in a piece of annealed iron the reduction due to the same steady force was more than 80 per cent.

§ 88. **Magnetic Viscosity under Small Forces.**—Allusion has already been made (§ 50) to the fact that after any change has taken place in the magnetic force acting on a piece of soft annealed wrought iron, some time elapses before the corresponding change of magnetic state is complete.‡ This magnetic viscosity is most noticeable when we have to deal with feeble forces or with small changes of force, and when the specimens tested are of considerable size. In such cases the time-lag in magnetisation may be so great that the ballistic method, which, of course, omits to take note of slow continuous changes, is not properly applicable.

In describing the experiments which were referred to in the last paragraph, Lord Rayleigh remarked that in applying small magnetic forces to *hard* iron or steel it was possible to adjust the compensating coil, so that neither at the moment of closing the magnetising circuit nor afterward was there any deflection—which means that, so far as the magnetometer can decide, these metals take their full magnetism at once. With annealed wrought iron, however, the effects were more complicated. "When the coil

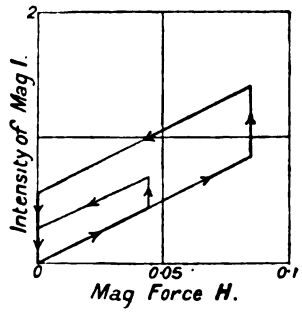

FIG. 57.

was so placed as to reduce as much as possible the instantaneous effect, there ensued a drift of the magnetometer needle in such a direction as to indicate a continued increase of magnetisation. Precisely opposite effects followed the withdrawal of the magnetising force. The settling down of the iron into a new magnetic state is thus shown to be far from instantaneous."

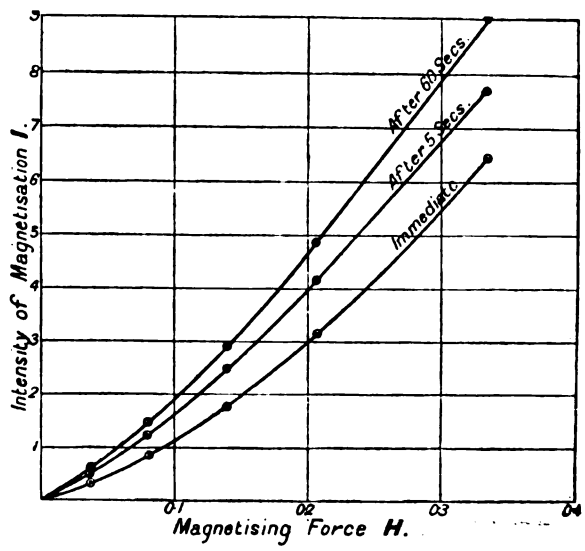

FIG. 58.—Effects of applying feeble magnetising forces to a soft iron rod.

Following Lord Rayleigh's plan of balancing the instantaneous effect by means of a compensating coil, and then observing the drift, the writer examined this time-lag in the magnetisation of a thick wire of annealed wrought-iron 0·404 cm. in diameter and 39·6 cms. long.* The wire was demagnetised by reversals to begin with, and feeble magnetising forces were used, not at first exceeding 0·1 C.-G.-S. So long as the force was less than this it was found that one adjustment of the compensating coil served to balance the instantaneous effect of making or breaking the current. When the compensation was correct the magnetometer needle began to drift slowly over as soon as the magnetising force was either applied or removed; and by observing the drift and adding that to the amount neutralised

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† *Phil. Mag.*, March, 1887.

‡ Phil. Trans., 1885, p. 569.—"When the magnetising current was applied to long wires of soft iron, either gradually or with more or less suddenness, there was a distinct creeping up of the magnetometer deflection after the current had attained a steady value. This action was sometimes so considerable as to oblige me to wait for some minutes before taking the magnetometer reading."

* *Proc.* Roy. Soc., June 20, 1889.

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by the compensating coil, the total magnetism after any time was readily deduced. A force of 0·044 C.-G.-S. was applied, and the instantaneous effect was to produce a value of I equal to 0·44 ; in five seconds this crept up to 0·58, and in 60 seconds to 0·67. Then the magnetising current was broken ; the instantaneous effect on I was to remove 0·44, leaving 0·27 ; in five seconds this residue fell to 0·09, and before 60 seconds it had completely disappeared. Next a magnetising force of 0·084 was applied. The value of I reached at once was 0·85 ; in five seconds it crept up to 1·20, and in 60 seconds to 1·40. On breaking the current, I fell at once to 0·55, after five seconds to 0·23, and after 60 seconds to 0·07. Possibly this small residue was permanent. These results are shown in Fig. 57. Precisely similar results were obtained by reversing feeble magnetic forces, the initial gradient of the lines being the same when the force was reversed as when it was applied and removed. If we measure the initial susceptibility by the immediate effect of applying or reversing H it is 10 ; if we measure it by the effect after one minute it is about 15.

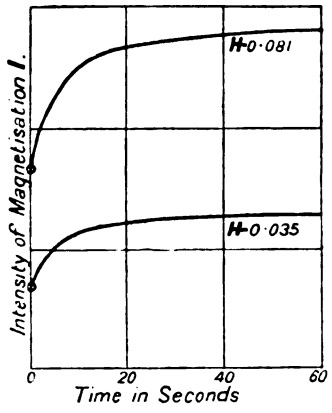

Fig. 59.—Growth of magnetism after applying feeble magnetising forces.

Fig. 58 shows the results of another experiment, in which successive forces were applied, ranging up to about 0·34 C.-G.-S., the compensating coil being adjusted for each force to give an instantaneous balance, so that the effect of the subsequent creeping up might be observed. Before applying each force the specimen was completely demagnetised. The three curves, Fig. 58, show the amounts of magnetism taken (*a*) at once, (*b*) after five seconds, and (*c*) after one minute. In noting the gradual growth of magnetism after each force was applied, readings of the magnetometer were taken every five seconds, and the two curves of Fig. 59 have been drawn from these, to show the time rate at which the process of creeping up went on under the action of magnetising forces equal to 0·035 and 0·081 respectively.

(To be continued.)

The Passive State of Iron and Steel.—In a Paper on this subject recently read before the Royal Society, Mr. Thomas Andrews gives the results of his latest investigations in this direction. The results afford an indication that magnetisation of comparatively low intensity, acting during considerable periods of time, exerts only a limited modifying influence on the passivity of iron or steel in the cold, though the influence is discernible when employing a delicate galvanometer. Magnetisation, with the nitric acid at a higher temperature, produces a quicker effect. In a recent research by the author, on "Electro-Chemical Effects on Magnetising Iron," it was noticed that local currents were set up between the polar terminals and central portions of steel magnets exposed as electrodes ; and this class of local action, together with the slight alteration of the physical structure of the magnet bars consequent on their magnetisation, may possibly be involved in producing the effects due to magnetism on passive steel or iron in concentrated nitric acid.

THE CAPE TOWN CABLE STATION.

BY H. D. WILKINSON.

With the extension of the system of submarine cables and the ultimate duplication of existing lines it becomes a matter of necessity to have means for storing cable at convenient points on shore, where it may be kept in good condition, and drawn from as required by the repairing steamers. For this purpose tanks have been erected on shore at Gibraltar, Malta, and Suez, in which cable is stored for the maintenance of the network of cables in the Mediterranean, while there are also tanks at Perim, and storage hulks moored off Zanzibar and Mossamedes for the same purpose. And now that, with the exception of the Government land lines between Cape Town and Natal, the dark continent is completely encircled by submarine cables, it has been decided upon by the Eastern and South African Cable Company, whose lines extend between Aden and Delagoa Bay on the East, and between Cape Town and Loanda on the West Coast, to erect tanks with ample storage capacity at the terminal station of Cape Town. The usual practice is to construct the tanks of riveted iron plates, similar to those on board cable-ships, and to erect them inside a covered shed of light angle-iron girders. An exception to this exists at Malta, where the tanks, or rather wells, are of concrete, opening flush with the ground.

The site for the tank-house at Cape Town has been selected on the promontory of land from which the new breakwater starts, immediately overlooking the docks. From this situation cable can be conveniently led over to a cable-ship in dock by simply crossing the dock road on overhead leads. The building, which is of corrugated iron, covers a space of nearly 6,000 square feet. In Fig. 1 we have a sectional view of the building, showing the position of the tanks. Derricks are erected as shown, on which to suspend the leading-in pulleys, and at the point of entering or leaving the shed the cable passes between two vertical rollers (Figs. 1 and 3). The sectional view shows the arrangement of pulleys and hauling gear. For the latter an engine and boiler are fixed as shown. The engine is an ordinary double-cylinder winch-engine, with 7in. cylinders and 15in. stroke, fitted with reversing gear. The motion is transmitted to the hauling pulley by a vertical shaft driven from the engine and connected by speed-reducing bevel gear. Altogether the speed is reduced in the ratio of 8 : 1.

The cable passes, as shown, over the V pulley, being kept down in the groove by the jockey-wheel J (Fig. 1), mounted on a lever with weight attached ; while the speed and direction are controlled by the engine the necessary grip on the cable for hauling is controlled by the position of the weight. The rim of the jockey-wheel is turned slightly concave to take the cable; but an improvement in this is to construct the wheel in two halves, adjustable towards or from each other, so as to fit over and grip any type of cable, from type D to the heavier types.

The shed contains three tanks, the centre one being 30ft. diameter and 6ft. deep, while the two others are 40ft. diameter and 8ft. deep. These have a total capacity of over 500 miles of cable. The cable passes over anti-friction pulleys fixed to the highest point in the span of the roof, and a platform is constructed at a convenient distance below them on which two or three men can work at keeping the cable taut. An improvement suggested by Mr. George Beckwith, the Company's engineer, under whose charge the erection of the plant has been carried out, is to place a second V pulley and jockey-wheel at the distant end of the shed to assist in the hauling and taking-up of the slack when cable is being led in to the further tank, the same being connected to the driving power by an overhead horizontal line of shafting. This arrangement would dispense with the hand labour of three men

Each tank is provided with an inlet and outlet service, by which water can be admitted or drained off, the inlet pipes being connected to the Harbour Board pumping engine in the docks supplying the convict station. The tanks are bedded on to a foundation consisting of rough concrete, 1ft. 6in. deep, covered with a 1½in. layer of cement and sand. Before this layer has set, the tank is let down and grouted in all round. A layer of cement is also run into the interior of the tanks,

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this being 1½in. deep round the circumference and sloped down to 1in. at the centre to assist in draining off. The leading pulleys over which the cable passes to the tanks are mounted on rollers R R, as shown (Fig. 2), reducing the friction to a minimum. A suitable testing-room is also fitted up in the tank-house, and provided permanently with instruments.

The last section in the chain of cables on the East Coast was laid as recently as last year. This connects the port of Mossamedes with Cape Town, the cable being 1,383 knots in length.

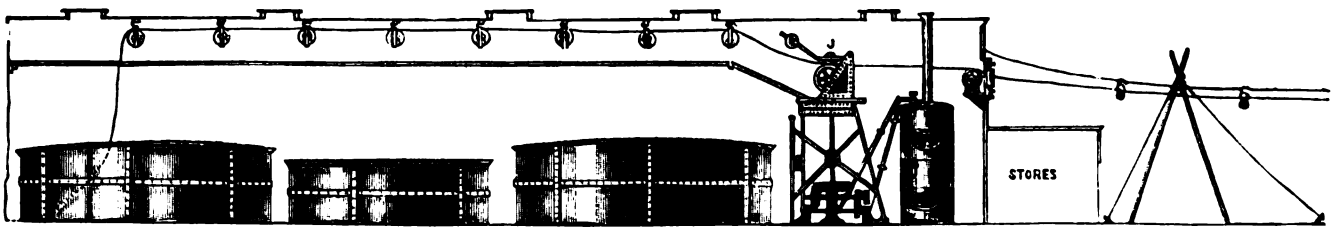

Fig. 1.—Cable tanks and hauling gear.

At a point some 384 miles from Cape Town a short length of cable is connected on to this cable by a T joint, and taken into the intermediate station of Port Nolloth. This joint, instead of being completely armoured over as in an ordinary joint, is enclosed and sunk in a cast-iron box. The strain is then taken off the joint by turning back the wires of the armour through holes in the box, and making them

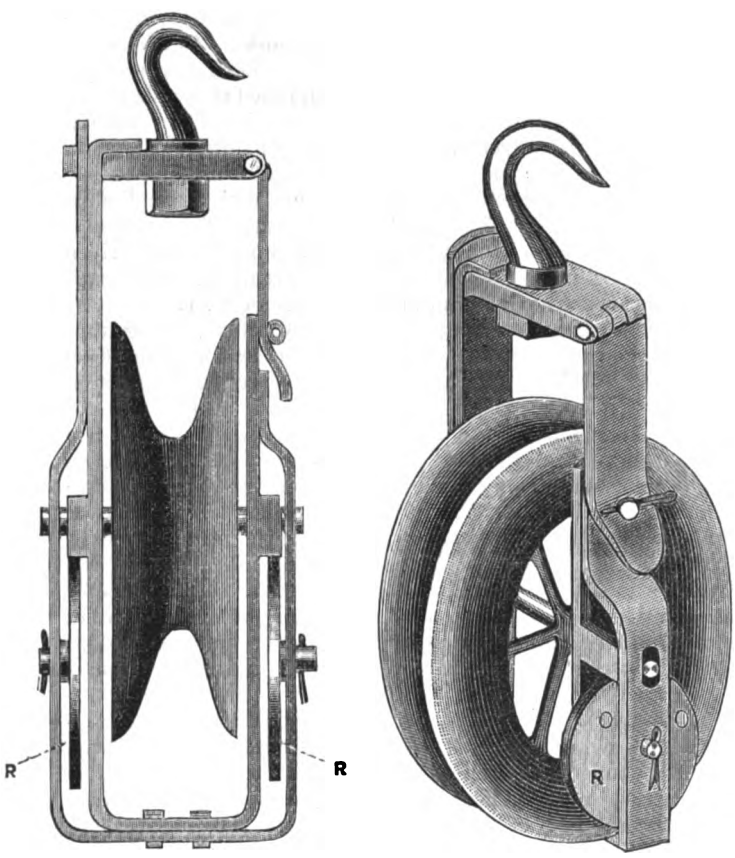

Fig. 2.—Anti-friction cable lead.

fast to the main cables. At Cape Town the cable has been laid round the outer bend of Table Bay, well outside the limits of the anchorage, and its course indicated by a series of mark buoys. The Cable House stands close to the old jetty at the bottom of the main street (Adderley-street), and is connected to the office in the same street by about a quarter of a mile of type D laid underground. The office itself is situated in the Standard Bank Buildings, the finest and most prominent building in this thoroughfare, and consists of an instrument room, battery and testing room, store room, and receiving office on the ground floor, and superintendent's office on the first floor. One remarks on entering that there is ample room for everything, not often the case in cable stations, and that the rooms are particularly lofty. One syphon recorder is, of course, only necessary, as messages for stations in the Colony and for the West Coast pass over the Government land lines, and are handed over to their offices. A mirror instrument is, however, kept in reserve. The recorder is of the latest pattern (see *Electrician*, June 20, 1890, p. 170), permanent magnets being employed. By reference to the signals on this cable herewith reproduced (Fig. 4), it will be seen that they are for this length of cable, and the vibrator method of driving the ink very clearly defined. The line has a capacity of 549 microfarads, a resistance of 8,832 ohms, an insulation of 8,500

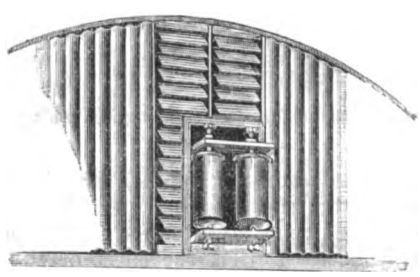

Fig. 3.—In-leads to tank house.

megohms per knot, and 20 microfarads are signalled through at each end.

This account of the station, though so brief, could not well be considered complete without some mention being made of the staff quarters. These are well situated on rising ground in Caledon street, and from the upper balcony command a fine view of Table Bay. The house, known as Buckingham Lodge, is surrounded by a tastefully laid-out garden, and approached through a thick avenue of trees. There are some twelve rooms, besides mess room and billiard room; a certain portion being reserved for the superintendent's use. As this station, from its

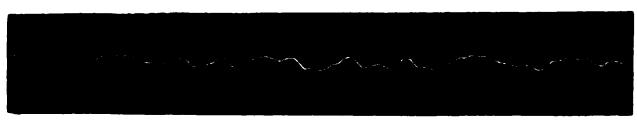

Fig. 4.—Signals on Cape Town Mossamedes cable. 1383 knots.

temperate and agreeable climate, is also used as a sanitorium for men who may be invalided from stations on the coast, the Company have spared no pains to make the quarters well appointed in every way. To the superintendent, Mr. Thomas Cassidy, is due most of the general arrangements for the comfort of the staff; and it is to his courtesy, and that of the staff working with him, that we are indebted for much of the information obtained.

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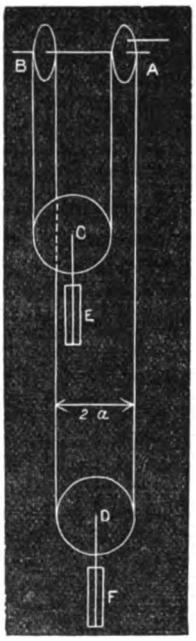
ON HUYGENS'S GEARING IN ILLUSTRATION OF THE INDUCTION OF ELECTRIC CURRENTS.*

BY LORD RAYLEIGH, SEC. R.S.

As a mechanical model of the electric machinery at work in the induction of currents Maxwell employed differential gearing; and an apparatus on this principle, designed by him, is in use at the Cavendish Laboratory. Wishing to show something similar in a recent course of lectures, and not having differential gearing at my disposal, I designed more than one combination of pulleys, the action of which should be analogous to that of electric currents. These eventually resolved themselves into Huygens's gearing, invented, I believe, in connection with the winding of clocks. As this apparatus is easier to understand than differential gearing, and the parts of which it is composed are more likely to be useful for general purposes in a laboratory, I have thought that it might be worth while to give a description, accompanied by an explanation of the mode of action.

Two similar pulleys, A, B, turn upon a piece of round steel fixed horizontally.† Over these is hung an endless cord, and the two bights carry similar pendent pulleys, C, D, from which again hang weights, E, F. The weight of the cord being negligible, the system is devoid of potential energy; that is, it will balance, whatever may be the vertical distance between C and D. Since either pulley A, B, may turn independently of the other, the system is capable of two independent motions. If A, B turn in the same direction and with the same velocity, one of the pendent pulleys, C, D, rises, and the other falls. If, on the other hand, the motions of A, B, are equal and opposite, the axes of the pendent pulleys and the attached weights remain at rest.



In the electrical analogy the rotatory velocity of A corresponds to a current in a primary circuit, that of B to a current in a secondary. If when all is at rest the rotation of A be suddenly started, by force applied at the handle or otherwise, the inertia of the masses E, F, opposes their sudden movement, and the consequence is that the pulley B turns *backwards*, *i. e.*, in the opposite direction to the rotation imposed upon A. This is the current induced in a secondary circuit when an electromotive force begins to act in the primary. In like manner, if A, having been for some time in uniform movement, suddenly stops, B enters into motion in the direction of the former movement of A. This is the secondary current on the break of the current in the primary circuit.

It must be borne in mind that in the absence of friction there is nothing to correspond with electrical resistance, so that the conductors must be looked upon as perfect. The frictions which actually enter do not follow the same laws as electrical resistances, and only very imperfectly represent them. However, the frictions which oppose the rotations of A and B have a general effect of the right sort; but the rotations of C and D, corresponding to dielectric machinery, should be as free as possible.

The effect of a condenser, to which the terminals of one of the circuits is joined, would be represented by a spiral spring (as in a watch) attached to the corresponding pulley, the stiffness of the spring being inversely as the capacity of the condenser. The absence of the spring, or (which comes to the same thing) the indefinite decrease of its stiffness, corresponds to infinite electrical capacity, or to a simply closed circuit.

The equations which express the mechanical properties of the system are readily found, and are precisely the same as those applicable in the electrical problem. Since the potential energy vanishes, everything turns upon the expression for the kinetic energy. If x and y denote the circumferential velocities in the same direction of the pulleys A, B, where the cord is in contact with them, $\frac{1}{2}(x+y)$ is the vertical velocity of the pendent pulleys. Also $\frac{1}{2}(x-y)$ is the circumferential linear velocity of C, D, due to rotation, at the place where the cord engages. If the diameter be here $2a$, the angular velocity is $(x-y)/2a$. Thus, if M be the total mass of each pendent pulley and attachment, Mk^2 the moment of inertia of the revolving parts, the whole kinetic energy corresponding to each is

$$\tfrac{1}{4}M\left\{\frac{(x+y)^2}{4}+\frac{k^2}{a^2}\frac{(x-y)^2}{4}\right\}.$$

For the energy of the whole system we should have the double of this, and, if it were necessary to include them, terms proportional to x^2 and y^2 to represent the energy of the fixed pulleys. The reaction between the pulleys, A, B, depends upon the presence of a term xy in the expression of the energy. We see that this would disappear if $k^2=a^2$; as would happen if the whole mass of the pendent pulleys and attachments were concentrated in the circles where the cord runs. The case discussed above, as analogous to electric currents, occurs when $k^2<a^2$, a condition that will be satisfied, even without non-rotating attachments, if the cord run near the circumference of the rotating pulleys. The opposite state of things, in which $k^2>a^2$, would be realised by carrying out masses beyond the groove, and thus increasing the rotatory in comparison with the translatory inertia. In this case the mutual action between A and B is reversed. If when all is at rest A be suddenly started, B moves forward in the *same* direction. Otherwise C and D would have to rotate, and this in their character of fly-wheels they oppose.

Generally, if L, N be the coefficients of self-induction, and M mutual induction, we have (constant factors being omitted)

$$L=N=a^2+k^2,$$
$$M=a^2-k^2.$$

In order to imitate the case of two circuits coiled together in close proximity throughout, we must have in the mechanical model $k^2=0$; that is, the rotatory inertia of the pendent pulleys must be negligible in comparison with the translatory inertia. Also the energy of the fixed pulleys, not included in the above expressions, must be negligible. If these conditions be satisfied, a sudden rotation imposed upon A generates an *equal* and opposite motion in B.

* *Phil. Mag.*, communicated by the Physical Society.

† Light wooden laths, variously coloured and revolving with the pulleys, render the movements evident at a distance.

NOTE ON A NEW PHOTOMETER.*

BY EDWARD L. NICHOLS.

Methods of photometry, which take no cognisance of differences of quality, are so ill adapted to the study of sources of light which differ from each other widely in temperature, that the introduction of some instrument by means of which both the character and intensity of an illuminant can be readily determined, would be a desirable adjunct to the equipment of our photometer rooms. The instrument which it is my purpose to describe has been designed to meet this need. Existing types of the spectrophotometer may be made to give good results, but they are expensive instruments, and so difficult to use that it is only in the hands of observers of considerable experience that accuracy is assured.

The new apparatus, the "horizontal-slit" photometer, is, in point of fact, a spectrophotometer, in which the polarising device is entirely done away with. In it the extremely simple principle of the Bunsen photometer is applied successively to the various regions of the visible spectra of the source of light which are to be compared. A direct vision spectroscope of Browning's form is attached to the usual car of a Bunsen photometer, from which the disc and mirrors have been removed. The optical axis of the collimator is horizontal and at right angles to the photometer bar. The slit is horizontal and lies in a straight line joining the sources of light, which are set up in the usual manner at the ends of the bar. The bar itself is preferably of considerable length—in the case of the one upon which the original instrument under consideration was mounted it was 500cm. long—and should be divided into 1,000 equal parts. In front of the spectroscope slit are placed two right angled prisms of the same size, and made of the same glass (see cut). Their vertical adjacent edges bisect the slit, and light travelling from either end of the photometer bar is totally reflected by them, and enters the right and left hand end of the slit in a direction parallel to the optical axis of the collimator tube. The two sets of rays thus gathered into the spectroscope from the lights at the end of the bar are vertically dispersed by the Amici prisms, and appear in the field of view as two vertical spectra standing side by side. Equal wave lengths are in the same horizontal line, and any desired region may be brought into the centre of the field by an angular movement of the ocular telescope. The telescope moves along the arc of a suitably divided semicircle, to which it may be clamped by means of a set screw. Wave lengths, corresponding to the various circle settings, are determined once for all by observation of the more prominent of the Fraunhofer lines.

* Paper read before the American Institute of Electrical Engineers at Boston.

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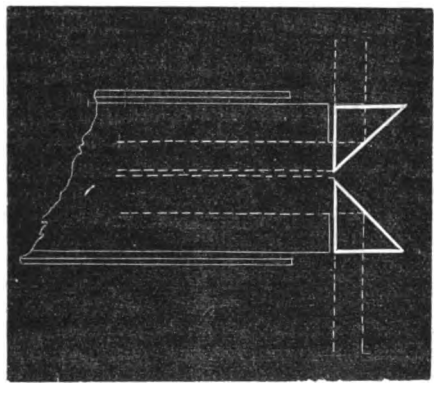
When the instrument thus mounted is placed at the middle of the photometer bar between lamps which are identical in intensity and quality, the two spectra are of equal brightness throughout, wave length for wave length, from red to violet. If the two lamps differ in intensity but not in quality, the two spectra will differ in brightness by the same amount from end to end, and a position may be found upon the bar for which they will be identical throughout. Under these circumstances, which are the only ones in which the Bunsen method in photometry is strictly applicable, the instrument may be used as a simple photometer, the setting for any wave length whatever giving the candle-power. For this purpose alone, viz., for the comparison of lights of similar character, the instrument offers certain manifest advantages over the various forms of the Bunsen photometer. In the course of the present Paper I shall present some definite data concerning the relative sensitiveness of the two instruments when used in this way.

When the lights to be compared differ both in intensity and quality, ordinary photometric indications possess no perfectly definite significance. In this, which is the more general case, the relative brightness of the spectra of the two sources varies with the wave length. For each region of the visible spectrum, however, a position upon the photometer bar can be found at which the brightness of the two spectra in that region will be equal; and the observations thus obtained, when extended over the entire spectrum, will afford data by means of which the differences in quality of the two sources of light may be definitely expressed.

In a recent Paper read before the Institute of Electrical Engineers, for a considerable range of temperature at least, the ratio between the intensities of a certain wave-length of the spectrum of glowing carbon, is identical with the ratio of candle-powers, as determined by the Bunsen photometer. The wave length in question, determined from the intensity of the spectrum of incandescent lamps at various candle-powers, I had found to be approxi-



mately $\lambda = 600$. M. A. Crova, in an important Paper presented at the late Electrical Congress at Paris, has pointed out the importance of this method of measuring the light from sources differing in temperature. The wave length which he has indicated for this purpose is $\lambda = 582$, which belongs to a region lying slightly farther towards the green than the one which I had adopted. When the wave length of this region has been established beyond question, the photometry of lights which vary in colour will have been reduced to a definite scientific basis. Instead of attempting to use the Bunsen photometer in measurements to which it is not adapted, we shall be able to deduce the relative candle-power of two sources of light from the comparison of a single wave length, and we shall be freed from the uncertainty arising from differences of colour and from the personal errors due to the independent use of the two eyes in observation. The determination of candle-power will then be an operation of precision, even when the sources of light to be compared vary widely in temperature. It is in the opportunity of performing such observations upon the photometer bar itself, under conditions which do away with many of the sources of error inherent in the usual methods of spectrophotometry, that the chief advantage the new photometer will be found to lie.

The following set of observations, taken with the new instrument, may serve to indicate one of the uses to which it may be put. The data are taken from an investigation now in progress in the physical laboratory of Cornell University. The object in view was to compare the spectrum of a novel type of gas burner with that of an ordinary argand burner. The two lamps were set up at the ends of a photometer bar five metres long, the bar, as already stated, being divided into 1,000 equal parts. Readings were taken at six points in the spectrum. The purposes being to express the relative brightness of the two spectra, wave length for wave length; the intensity of that due to the argand burner was taken as unity throughout, and the brightness of each region of the spectrum of the flame under investigation was obtained in terms of that of the corresponding region of the spectrum of the argand. The results are given in Table I. :—

Table I.—*Comparison of the Spectrum of a Welsbach Burner with that of an Ordinary Argand Burner by Means of the "Horizontal-slit Photometer."*

From observations by Miss Ida M. Hill. (Ten observations were made in each region.)

Colour.	Wave length.	Light ratio, $\frac{\text{Welsbach}}{\text{Argand}}$.	Probable error of a single observation.
			Per cent.
Red	702	0·709 ± ·017	2·45
Yellow	589	1·476 ± ·017	1·14
	558	1·760 ± ·025	1·34
Green	500	2·395 ± ·047	1·99
Blue	466	2·738 ± ·036	1·30
Violet	439	3·090 ± ·073	2·35
		Average	1·76

I introduce these measurements here simply as an illustration of one line of work to which the instrument under consideration is adapted. A full description of the research of which they form a part, and which covers many other questions pertaining to the very interesting class of lamps with which it deals, will doubtless be published in due time. As will be seen from the column of probable errors, the sensitiveness of the instrument is greatest in the region of the D line ($\lambda = 589$), and least in the extreme red and violet, where the light intensities are small. A set of ten determinations made by the same observer with the Bunsen photometer gave for the total light ratio of the two lamps:

$$\frac{\text{Welsbach}}{\text{Argand}} = 1{\cdot}701 \pm {\cdot}015$$

The probable error of a single observation in this series amounted to 0·89 per cent., a value somewhat smaller than that obtained with the new photometer in the yellow of the spectrum. The number of observations is too small to afford a close estimate of the relative sensitiveness of the two instruments, but the results suffice to show that the "horizontal-slit" photometer does not differ appreciably in accuracy from the Bunsen photometer when the latter is used in the comparison of flames of the same colour.

When it comes to the measurement of sources of light that differ widely in temperature the comparison is decidedly in favour of the "horizontal-slit" photometer, the sensitiveness of which is not affected by differences of colour. The error of the Bunsen photometer in candle-power measurement of the arc light, for instance, calculated from ten observations recently made upon the same photometer bar, the reference standard being an argand gas burner, was 2·65 per cent. (probable error of a single observation), a value more than twice as large as that of the "horizontal-slit" photometer. A comparison of the performance of the new photometer with that of a polarising spectrophotometer of the type which is commonly recognised as affording the highest degree of accuracy, is decidedly in favour of the former. Taking as a basis eight observations made by Mr. Franklin and myself in the study of a bat's-wing gas burner, the observations covering eight regions of the spectrum, I find the error of a single observation in the various regions to have been as follows :—

Table II.—*Probable Errors of a Single Observation with a Polarising Spectrophotometer, calculated from Sets of Ten Observations upon various Portions of the Spectrum of a Gas Flame.*

Wave length.	Probable error of a single observation.
	Per cent.
753	7·9
668	4·9
608	4·5
557	5·4
518	6·4
492	7·0
468	3·0
450	2·4
	Average..... 5·9

The measurement of a fluctuating illuminant, such as the gas flame, is a line of investigation by no means adapted to exhibit any photometric instrument at its best; but as the errors of the horizontal-slit photometer, already given, were calculated from sets of ten observations upon such flames, I have selected for comparison similar sets of ten upon sources of the same character. The averages, viz. :

Error of horizontal-slit photometer 1·76 per cent. (average for spectrum), error of polarising spectrophotometer 5·20 per cent.

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(average for spectrum), doubtless afford a fair indication of the relative performance of the two instruments in this peculiarly trying line of work.

At the last annual meeting of the Institute I had the privilege of presenting a brief study of certain personal errors pertaining to the use of the Bunsen photometer. The particular class of errors to which attention was called in that Paper are undoubtedly obviated by the use of the horizontal-slit photometer; what new ones the latter instrument may introduce remains to be determined.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—THURSDAY, June 26th.

London Overhead Wires Bill.

On the order for the consideration of this Bill,

Sir R. LETHBRIDGE rose to move that it be considered that day six months. He said it had been hoped that the Committee on this Bill would safeguard the rights of private residents; but the Bill conferred upon officials of the London County Council powers of compulsorily entering upon private property at any time for the purpose of putting up wires and inspecting them. Such powers had never yet been asked for in any Bill of this kind, and he trusted the House would never grant such powers to any persons whatever. It might be alleged that some means must be found to enable telephonic communication to be established; but it must be done without such interference with private rights. How it was to be done it was for the promoters of the Bill to suggest; but some method must be found against which the same objections could not be urged.

Mr. BARTLEY said the Bill would empower a Local Authority to put a pole on a house, whether the occupier liked it or not. At first the Bill was called a Subway Bill, and these wires ought to be laid in subways instead of being carried over houses and streets. He therefore hoped this Bill would be rejected and would be followed by one providing for subways for telephone wires.

SIR J. BAILEY said that the Bill in its present shape carried out exactly the report of the Select Committee of 1885, and the interests of the householder had been very carefully considered. The Bill gave the County Council power to formulate bye-laws for the regulation of overhead wires, and the enforcement of these bye-laws was entrusted to the Corporation in the City, and to the vestries and to district boards in the rest of the metropolis. The fears expressed by metropolitan members as to the effect of the Bill were absolutely unfounded. It was said that the Bill would empower the Council's officers by day or night to enter into private houses. Now, one of the great dangers of the overhead wires was that there were in London a great number of derelict wires, and therefore it was most necessary that workmen should be appointed by the Local Authorities to deal with the wires. Clause 8 of the Bill provided that the inspector of the Council might enter a private house provided he was in uniform, and was duly authorised in writing by the Local Authority, and provided that notice had been previously given. The inspector might then enter at some reasonable time to be named by the occupier. The rights of householders being thus most stringently guarded, he hoped the Bill would be read a third time.

Mr. LAWSON said that the London County Council had had very little to do with the drafting of the Bill. The question was one of public safety and convenience. It was absolutely impossible to force the telephone wires into subways; moreover, the bye-laws of the County Council would have to be approved by the Board of Trade and enforced by the district authorities. The "subways" had been dropped because that subject no longer had a place in the Bill. There could be no better arrangement than that the overhead wires should be placed under the central authority for London, acting through the various district authorities.

Mr. DIXON-HARTLAND said that he had unfortunately given a telephone company permission to put a wire over his house. Since that time the house had never been his own. The poles, moreover, were fixed so badly that considerable damage was done to the roof of his house. The Company declined to repair the damage, and it cost him £50 to put the roof in order when he applied for the removal of the poles. The question was not one of erecting telephone wires, but of erecting electric lighting wires, with the erection of which they were threatened all over London, and which was a much more serious matter. They were in the infancy of the system, and yet they had already realised that those wires greatly increased the risk of fire, a proof of which was that the insurance offices had raised the rates for that property to which electric lighting wires were fixed. He hoped the House would reject this ill-digested scheme.

Mr. BRADLAUGH urged that if the Bill passed an entirely new departure in legislation would be made; for under whatever authority the Bill was applied it would give an arbitrary power of interference with property, whether the owner objected or not, without compensation. The objections to the Bill were serious, and he trusted it would be rejected.

Sir J. LUBBOCK said the opponents of the Bill attacked solely two of its clauses, and it would surely be unreasonable to throw out the whole Bill on account of two clauses. As regarded Clause 11, the hon. member for Northampton said that the party seeking the right to put up a pole was itself to determine whether a refusal was unreasonable. That was not so; the London County Council were not owners of overhead wires, and had no interest except that of the public. Then, as regarded Clause 8, it was objected that the officers of the London County Council ought not to have any right of entry; but if they had the duty of inspection they must have some right of entry. The Bill was recommended by two Committees of the House, and he hoped the House would support the Committee.

Mr. COURTNEY remarked that this Bill had been considered by a Committee of that House, and no one could have listened to the speech of the hon. baronet who had presided over that Committee without feeling impressed with the care that had been given to the subject. He hoped, therefore, that the House would not reject in this summary manner what had been agreed to by that Committee. Another reason why they should reject this amendment was that the strongest objection against this Bill had been brought by the hon. member for Northampton, who objected to one clause of it. But even if that clause were struck out, there was much that was valuable left in the Bill, to which no substantial objection could be taken. This Bill dealt with the natural state of facts, namely, that there was a great number of overhead wires in London which formed a source of danger and inconvenience to the inhabitants of the metropolis, and it was most desirable that some authority should look after the wires. He ventured to submit that Clause 8, which had been objected to, was a very reasonable way of dealing with the question of wires already in existence, attached to houses by the permission of the owners and occupiers. He submitted that it was essential that there should be some authority able to say whether poles should be set up. The authority appointed by this Bill was the County Connecil, which had no private interest in the matter, and would only act as the guardian of the public interests. They could give notice to a person who, in their opinion, offered unreasonable objections, and if he continued to assert his objections the matter was referred to an arbitrator appointed by the Board of Trade. Those who were so devoted to the rights of property as to want special leave for the erec tion of every pole, could, if they choose, move that that clause should be rejected; but it was an entirely different thing to oppose a Bill which was admittedly a useful measure.

The House divided, when there were—

For the Bill	200
Against	203
Majority against	—3

HOUSE OF LORDS.—MONDAY, June 30th.

Central London Railway Bill.

This Bill, which has already passed the House of Commons, came on Monday before a Committee of the House of Lords, consisting of Lord Henley (Chairman), Lord Brassey, Lord Rowton, Lord Hamilton of Dalziell, and Lord Yarborough.

Mr. PEMBER, Q.C., in opening the case for the promoters of the Bill, explained the details of the scheme as set forth in *The Electrician* of April 25th. There were, he said, now 17 petitions against the Bill, as compared with 37 in the other House, where the parties appeared in only 19 cases. In only eight of the petitions the parties now appeared by counsel—viz., those of the Duke of Westminster, the Duke of Portland, Lord Portman, frontagers in Oxford-street, &c., the trustees of the Paddington Estate, Queen Anne's Bounty, the Dean and Chapter of St. Paul's, and the Ecclesiastical Commissioners. Several of the petitions set forth objections to the line on the ground of vibration and danger of subsidence, and a good many objected to the underpinning clause, which was a very usual clause. Other petitions objected to the taking of the subsoil of the street without money payment. The three engineers of the scheme, Sir John Fowler, Sir Benjamin Baker, and Mr. Greathead, had a great deal too much to lose to let their names be connected with a scheme that was at all risky, and the fact of their being the engineers ought to be a sufficient guarantee that the work would be carried out properly. The objections in this case were a distinction between fear and danger. Of fear there was a great deal, but of danger there was none. There was no allegation in any of the petitions in that House with regard to the finance such as there was in the House of Commons, where, doubtless, the Committee were satisfied on that point by the evidence of Sir Henry Selwin-Ibbetson, who was one of the promoters, together with such other gentlemen as the Hon. Anthony Evelyn Ashley, Mr. Ernest Noel, and Mr. Alexander Ravenscroft Robertson.

Evidence was then called in support of the opening statement of counsel, and the Committee adjourned.

TUESDAY, July 1st.

At the second meeting of the Committee Mr. GREATHEAD was called. Cross-examined by Mr. Jeune, Q.C., in reference to St. Paul's Cathedral, Mr. Greathead said that with regard to Sir Christopher Wren's description of the subsoil near St. Paul's, which he said was composed of loose water-laden sand and shells, he was of opinion that Sir Christopher was in error. He expressed the opinion that the subsoil was clay, but had made no borings. He would be happy to do so if he obtained permission. The borings would occupy about a week.

Sir BENJAMIN BAKER, C.E., was the next witness. He was strongly of opinion that the proposed scheme could be successfully carried out.

The Committee afterwards adjourned.

WEDNESDAY, July 2nd.

At the third meeting of the Committee Sir Benjamin Baker, Dr. John Hopkinson, and Dr. Edward Hopkinson were examined.

Sir BENJAMIN BAKER was of opinion that there would be no danger to passengers from impure air in the event of a train being accidentally detained in the tunnel for any length of time.

The Committee adjourned until Thursday morning.

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The Electrician.

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THE GAS COMPANIES AND ELECTRIC LIGHTING.

When discussing, as we have often had to do of late, the attitude towards electric lighting assumed by those Local Authorities who own gas works, we have always maintained that it is a matter of indifference to electrical trades whether the business of supplying electricity is carried on independently by them or is amalgamated with existing municipal gas undertakings. And this we still believe to be the case, always provided the amalgamation is effected with the honest intention of supplying and not extinguishing the new illuminant. The same arguments, with the same reservation, apply equally to private Gas Companies in general. If they took up the business of electric lighting with no other motive than to act fairly by it and by the public, there is reason to believe that electrical engineers would not suffer by the devolution, but rather that they would be the gainers. They are, therefore, able to discuss in an impartial spirit the further questions whether it would be to the advantage of the Gas Companies themselves to enter upon the business of electric lighting, and whether the public would in that case be as well served as they expect to be by the undertakings which are about to devote themselves exclusively to that line of business.

The latter of these propositions admits of an affirmative answer being given with little or no hesitation; for all the conditions seem to favour the old-established purveyors of light continuing to serve the public as they have done for generations past, even though the article supplied has undergone a material change. The Gas Companies, it is true, have never possessed a monopoly of every form of lighting; candles and oil are still outside the sphere of their operations; and into whatever hands electric lighting may fall, some applications of it would remain with private undertakers, just as in some instances does the manufacture of gas. But for public and domestic purposes lighting by means of gas and by means of electricity are operations sufficiently alike to

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warrant their being conducted by one and the same contractor, and even to recommend it on economic and administrative grounds. The companies have a large command of capital, they possess the necessary organisation, they would have the same demands to satisfy, and they have had experience in satisfying them which none but themselves can pretend to. Not only this, they are already in almost complete possession of the field, and could supplement their existing plant and appliances with the requirements for the new illuminant at less cost and perhaps with greater efficiency than could any rival undertaker. The argument on public grounds therefore seems to be unanswerable, and we have by no means exhausted it.

Something, no doubt, can be said on the other side, chiefly based on the prejudice which undeniably prevails against existing monopolies. But, without discussing the justice or injustice of that prejudice, it may be confidently asserted that the public have no interest in, and would not benefit by the extinction of such monopolies to their financial ruin. So far, therefore, from the prospective successful rivalry of the electric light being an argument for its elevation to a position of independent monopoly, it is rather a reason for desiring its absorption by the ancient and still thriving monopolists. If there is to be, sooner or later, a desperate competition between the two systems of lighting, it will be to the detriment of both; and it is hardly doubtful which of the two would suffer most. Almost certainly the electric light will be hampered in its progress, if not permanently enfeebled, by competition directly that period of conflict is reached; and from this point of view also, if they want the electric light, the public would not be averse to its being supplied by the existing Gas Light Companies.

The other proposition touching the interests of the Gas Companies themselves is not so easily answered. But it is one that they will have to consider and answer before many years are over. At present we see hardly any disposition among the directors or shareholders to give the question the attention it deserves; and we know of only one gas undertaking in England—and this a municipal body—that has taken up the business of electric lighting, although numerous instances of the kind are occurring in America. Nevertheless, the subject is being seriously discussed in, at least, one influential organ of gas industry in this country; and at the recent annual meeting of the members of the Gas Institute a Paper was submitted and printed, though not publicly discussed, putting the question categorically, "Shall Gas Undertakings supply Electricity?" and answering it with an emphatic Yes. The writer affirms, though we cannot corroborate his figures, that there are already in America quite 100 Gas Companies supplying electricity in connection with one system —the Thomson-Houston—alone; and surveying the progress which electric lighting is making here, and may be reasonably expected to make, in the hands of its present promoters, he presents the issue in the following pertinent query: "If things continue like this, where will the Gas Companies be in a few years time? They will have in every district where there are gas works, an Electric Light Company competing with them, and then they will see that it would have been well if they had obtained a footing themselves." What follows is more problematical. "Assuming," says the author, "that Gas Companies supply electricity, and looking into the far future, who knows but that gas works will become electric light works, and that, as the electric light enters into universal use, so will gas die out?" If gas undertakers could be persuaded of this, they would assuredly lose no time in acquiring Provisional Orders for supplying electricity. What deters them at present is their confidence in the supremacy of gas, and their scepticism as to the future of electric lighting. To a similar question propounded at a recent meeting of the American Western Gas Association, the president answered, "In some situations, yes; in others, no." Probably he meant Yes where there is a vigorous demand for it, and No where there is not. English Gas Companies are perhaps waiting for the demand which will satisfy their ideas of vigour. When that time arrives, however, the supply will not be so easy of acquirement. But we do not share the apprehensions of some of our readers that the Gas Companies would not supply the electric light with sufficient liberality. That must depend entirely on the reality and extent of the demand; and to assert that the Gas Companies would not respond to it, is equivalent to a confession that the demand may not be great enough to make the business remunerative—a conclusion as discouraging to Electric Light Companies as it would be welcome to Gas Companies. In short, if the former succeed in their venture the latter could hardly fail to succeed likewise; and, without in the least desiring it, much less recommending it, we have not the least doubt that the gas undertakers will become electric lighting undertakers directly they find it is to their interest to adopt that course.

OBITUARY.

M. AUGUSTE FREY.

We regret to announce the death of M. Frey, the Director of the International Telegraph Bureau at Berne.

M. Frey became Director-General of Swiss Telegraphs in April, 1873, and in that capacity attended the Telegraph Conferences of St. Petersburg, London, and Berlin. Last March he was appointed Director of the International Bureau, in succession to the late M. Curchod; and although suffering from a painful internal malady the doctors thought he had at least two years' work before him. However, when the Paris Conference opened in May he was unable, through illness, to be present, and his absence was feelingly alluded to by Mr. Lamb in the last sitting of the Conference, on 21st ult.

M. Frey was a man of genial habits, and made himself generally liked and appreciated by all who knew him.

MR. JOHN BOURDEAUX.

We regret to record the death, after a long illness, on Wednesday last, at the age of 55, of John Bourdeaux, who was the Chief Engineer of the Submarine Telegraph Company up to the time of the acquisition of its cables by the Post Office.

Mr. Bourdeaux was one of the few remaining representatives of the earlier telegraphists, having entered the service at the age of 14. In his time he probably repaired more shallow-water cables than any other cable man.

ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

§ 1. **Transformer Systems.**—The employment of the alternate-current transformer for electric-current distribution has changed in many respects the practical possibilities of the supply of electric energy for lighting purposes in large towns and in districts in which great distances, comparatively speaking, separate the centres of consumption and supply. By its aid it has become possible to deal with problems in electric distribution which are less amenable, or perhaps, commercially speaking,

* This series of articles is a continuation of those which appeared in *The Electrician* under the title of "The Alternate Current Transformer," by the same Author, and which have since been largely extended and republished in book form. All rights are reserved.

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unprofitable, when attacked by other methods; * and its enormous extension in six or seven years in Europe and in America is in itself evidence of the utility of the method. In examining the results as a whole that have been obtained by the employment and adaptation of the transformer for this purpose, we shall proceed to describe the principal systems at work, and the details of the installations of transformer systems in typical places in which it has established itself as a fit solution of the practical difficulties which there presented themselves to be overcome. The systems now occupying positions of importance, and on the lines of which, in different places, electric distributions of varying degrees of magnitude are being carried out, are chiefly those connected with the names of Ganz and Co., of Budapest, operating the methods of Messrs. Zipernowsky, Déri, and Bláthy; the Westinghouse Electric Lighting Company, and the Thomson-Houston Electric Lighting Company, in the United States, operating the systems elaborated by the well-known inventors connected with them. In England, the now familiar systems of the London Electric Supply Corporation (Mr. S. Z. de Ferranti), the Brush Electrical Engineering Corporation (Mr. Mordey), and the House-to-House Electric Lighting Company (Messrs. Lowrie, Hall, and Parker). The Metropolitan Electric Supply Company of London, employing for the most part methods and machines of the Westinghouse Electric Light Company, as well as Elwell-Parker

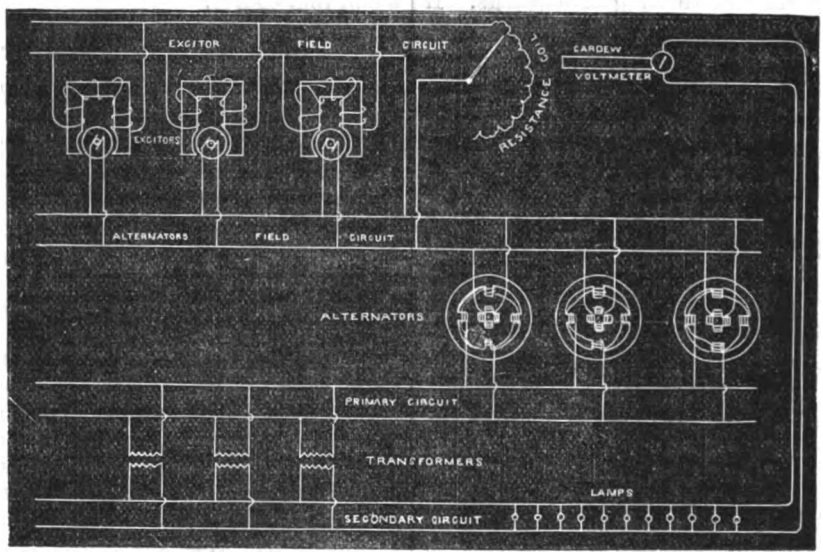

FIG. 1.—Arrangement of Alternators, Exciters, and Transformers in Ganz system of Electrical Distribution.

dynamos and transformers, may be considered as a connecting link between English and American ideas. This list by no means exhausts the names of designers or manufacturers of transformers, or of its necessary adjunct, the alternating dynamo. Apart from efforts of pioneers we have excellent designs for these separate elements connected also with the names of Messrs. Siemens, Gramme, Hopkinson, Goolden, Kapp, Wilde, Snell, Swinburne, Sharpe and Kent, Elwell-Parker, R. Kennedy, and many others; but the above-named six or seven complete systems comprise for the most part the best known apparatus in wide use for the distribution of electric energy by transformers; and some account of the machines, appliances, and methods in use by each respectively, taking typical examples, will now be given. The order in which they will be mentioned has, however, no reference to their historical order of development, nor to their relative importance.

§ 2. **System of Ganz (Zipernowsky, Déri and Bláthy).**—The methods of transformer distribution, which have been elaborated and put into execution by the inventive ability of Messrs. C. Zipernowsky, M. Déri and O. T. Bláthy, of Budapest, have enabled the great firm of Ganz and Co. to establish a special electric lighting department and to undertake on a large scale the production of all the appliances and details which have been worked out into the complete system which bears their name. Nearly seventy central stations of different degrees of magnitude have been set in operation by them up to the present time (1890), in which electric energy is distributed to arc and incandescent lamps from central stations, about 1,000 arcs and 100,000 incandescents being in all supplied. The elements of this system comprise (i.), An alternating-current dynamo machine; (ii.), An exciting continuous-current dynamo; (iii.), The alternating transformers; and (iv.), Special regulating devices, which have for their object the maintenance of a constant pressure, irrespective of consumption, at some point or points in the distributing system. The system may be described as a *parallel* system in its entirety, that is to say, the exciting dynamos are arranged in parallel between two exciting mains, the field-magnets of the alternating-dynamos being in parallel between the same mains (*see* Fig. 1). The armatures of the alternators are arranged in parallel between a pair of primary mains, working, if need be, in step with each other, and the primary coils of the transformers are all arranged in parallel between the same primary mains. The secondary circuits of the transformers are arranged in parallel with the lamps between the same secondary mains. The exciting dynamos are shunt dynamos, and the field-magnets circuits of these dynamos are also all arranged in parallel, and take currents off the main circuit of the exciting dynamos, into which the armatures of the exciters are as well all joined in parallel. There is a variable resistance interposed in the circuit of all the fields of these exciters, by the variation of which the strength of the exciter field can be varied, and hence the electromotive force of the exciters. The field-magnet circuits of the alternators being all joined in parallel with each other, and with the armatures of the exciters, it is obvious that the variation of this intercalated resistance can be made to change the strength of field of the alternators; and hence the electromotive force of these machines within certain limits. The transformer circuits are joined in parallel between the primary and secondary mains. From some points in the secondary distribution system, which may be called the electrical centre of the network, a pair of voltmeter wires can be brought back to the station; and by an arrangement presently to be described, the regulating resistance can be properly varied so as to keep the electric pressure at this electrical centre of distribution constant. Voltmeter wires, or *feeling wires*, may be brought back to the station from more than one point, and the pressure at any one of these points regulated as the demand for current requires. The variation of one resistance controlling the field of the excitors, therefore, is able to effect the regulation of the electric pressure in the secondary circuits over large areas of distribution.

(To be continued.)

* The arguments *pro* and *con* in the case of alternate transformers and secondary batteries for central station electric lighting need not be entered into here; but we refer the reader to Mr. R. E. Crompton's excellent Paper, and the discussion thereon in the *Journal of the Institution of Electrical Engineers*, Vol. XVII., 1888.

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THE POST-OFFICE JUBILEE CONVERSAZIONE.

A brilliant gathering at the South Kensington Museum, which rarely before held so many visitors, celebrated the jubilee of the Penny Post on Wednesday last.

The work of the Post-Office, sorting, stamping, and making up mails, was busily carried on among the classical statues; and in one of the longest galleries was displayed a collection of historical and modern telegraphic apparatus.

Amongst the recently developed instruments were specimens of the double sounder, which consists of two plate sounders, tuned to different notes, as in the Bright's bell. The peculiarity of the instrument is the hood which covers the sounders and the relay. Its shape is suggestive of a hall porter's chair. The sides are made of wood, and the curved back is composed of a sheet of perforated zinc, covered on each side with thin mahogany veneer. This has been found to give a remarkably sonorous resonance; the shape is the outcome of experiments with the view of focussing the sounds on to the ears of the operator. Several of these instruments can be used side by side, without any confusion of sound. A specimen of the instruments used with the latest development of Delaney's multiplex system are shown. The contact ring is provided with 144 working segments, besides correcting segments. When the instrument is worked with six circuits, each one receives a current from 24 contacts in one revolution of the rotating arm. Each operator therefore receives a current 72 times in a second, a speed which, if he is not aware that he was on a multiplex line, would convince him that his circuit was being worked with a continuous current, and at the same time, would convince five others, whose messages have to pass during the pauses of which he is unconscious. The La Cour phonic wheel, which is used to synchronise the transmitter and the receiver, is worked with a vibrating reed, making 90 vibrations per second. There are 30 armatures on the wheel, and it is, therefore, driven at three revolutions per second. Although a current of 0·2 ampere is sent through the contact maker on the reed, all sparking is prevented by the use of a condenser shunted round the magnet. In dealing with these pulsatory currents, the relay used is of considerably larger dimensions than the ordinary pattern. A large self-induction is produced by an increased number of turns of wire, and by the use of a large iron core. A condenser, coupled as a shunt to the coil, discharges during the time of disconnection; and the current so discharged, coming between the two portions of the main current, fills up the gap to a great extent, and tends to convert a discontinuous current into a pulsating current. Each instrument will work with as little as half a milliampere, but six milliamperes are used in practice. The pulsatory current requires the use of higher volts; but the current on the line is actually less than with a Wheatstone, which needs fewer cells, but 25 to 30 milliamperes. The Post-Office line men say that a live multiplex line is considerably more comfortable to handle than a Wheatstone. Among the rows of complicated glittering instruments which seemed almost out of place among the brilliant dresses of the thousands who thronged the corridors, was a length of a few feet of a telegraph post, having a large hole, which had been excavated by a woodpecker. A stuffed bird of this kind—a remarkably fine specimen—was mounted as if at work on the post, under the impression that the noise of the wind among the wires was due to the "murmuring of innumerable bees," or whatever insects form the food of the pretty creature. A bird mounted in a similar way was shown at the Paris Exhibition of 1881; but this is a real English specimen, shot only a few months ago.

The historical display included a collection of insulators, showing the gradual development of their design. Beginning with a mere porcelain ring, the surface was increased, and the insulator took the form of two solid cones, base to base. Then it assumed an hour-glass shape, or two hollow cones, point to point, the wire in both cases running through the axis. Then a suspending hook-shaped insulator was tried, first of porcelain, and then of glass, and was provided with a zinc cap. This was intended to act in the same way as the zinc cap which is used on the end of an astronomical telescope, viz., to concentrate upon itself the formation of dew. It unfortunately extended its accommodation to spiders. It was, as might be guessed, the invention of Mr. Latimer Clark. The next pattern, in which the cap was made of glass, was too fragile. The cap insulator was then introduced by Varley, and a few modifications and an increase in size resulted in the ordinary Post-Office pattern of insulator.

The great attraction of the evening was undoubtedly the electrophonoscope, which was exhibited to illustrate what telegraphy is likely to be in 1990. It is the joint invention of two gentlemen who are the highest authorities on the construction of delicate mechanism of telegraphic instruments, and who have had the collaboration of the Post Office officials. Some four or five different suggestions have been made from time to time of methods whereby it might be possible to enable a distant object to be seen by the aid of electricity. All these have depended upon the use of selenium, a most disappointing material for the purpose. These schemes all depended upon an optical illusion produced by points illuminated in rapid succession, or by quickly-moving mirrors. While the present system has something in common with the latter method, the illusion is of a very different nature. The system is not patented, and we can say nothing more about it but that the mechanical details of construction which we were allowed to examine were admirably adapted for the purpose; and the result was, of its kind, nearly perfect. The sender of the message, speaking through a telephone, sees with very fair distinctness the person at the distant end, and *vice versa*, the face of each being brightly illuminated by electric light.

THE MAGNETIC CIRCUIT.

BY E. T. CARTER.

The principle of the magnetic circuit having now become so generally recognised, and so universally adopted in practical work, it will be instructive to compare some of the points of analogy between it and the electric circuit. The "Ohm's law" of the magnetic circuit is an accomplished fact; and the employment of it has greatly facilitated electro magnetic calculations. We have laws of magnetic "conductors" in series and in parallel; of opposing or helping magneto-motive forces distributed round the circuit, either in branched or main parts of that circuit; we might even with safety, and possibly with advantage, use the terms "impedance," "back M.M.F.," "resistance equivalent," and many other terms that are employed in the discussion of electric circuits; for the ideas expressed by them are common to magnetic and electric circuits. It is my intention, in this Paper, to carry the points of this analogy a little farther than is usually recognised among practical engineers, hoping that the result may prove of some value to all who deal in matters magnetic.

The theoretical conceptions of magnetic and electric potentials at any point in a field of force are identical. In each the potential is measured by the line integral of the force exerted when unit quantity is moved from the boundary of the field to the point in question. The potential difference, therefore, between any two points is the work done in moving a unit charge (if the field is electrical), or a unit pole (if the field is magnetic), from one point to the other. Imagine a unit charge (electro-magnetic) inserted into an electric circuit at any point, it will tend to move along with the current; that is, its potential will tend to fall. But if we push this unit charge up the circuit against the current we raise its potential, and do an amount of work which is a measure of this rise. The work done may be expressed either as the line integral of the force acting on the charge, or as a function of the electrical resistance of the path taken by the charge and the current opposing it. In mathematical language—

$$\text{P. D.} = \text{W} = \int_0^l \text{F} \,.\, dl = \int_0^R \text{C} \,.\, d\text{R}.$$

The former of these integrations depends upon our conceptions of force and energy; the latter upon our notions of the re-

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lation between current, resistance and potential difference. It must be further explained, however, that the latter expression is accurate only when there are no E.M.F.'s actually in the path of the carried charge. When such E.M.F.'s exist—

$$\text{P. D.} = -\Sigma e + \int_o^R C \,.\, dR,$$

where Σe is the algebraic sum of these E.M.F.'s. This can be transformed into

$$\text{P. D.} = -\Sigma e + \int_o^R C \,.\, d\,\frac{l}{k\,A} = -\Sigma e + \int_o^l \Delta \,.\, d\,\frac{l}{k},$$

where

Δ = current density,
A = sectional area,
k = specific electrical conductivity,
l = length of conductor whose potential difference is P. D.

Now, if the charge is carried completely round the circuit its P. D. is not finally altered.

$$\therefore \Sigma e = \int_o^l \frac{l}{k}\,\Delta \,.\, d\,\frac{l}{k} = \int_o^l F \,.\, d\,l,$$

which shows that the effective E.M.F. in any circuit-carrying currents may be measured by the line integral of the force exerted on a unit charge moved once round the circuit against the current, any path in the conductor being taken; or that it may be measured in terms of current density, specific conductivity, and length of circuit. In practice the latter method is the one employed, with slight modification.

Considering, now, the magnetic circuit: if a unit pole is placed in the circuit anywhere, and carried along against the lines of induction, its potential is raised, and the work done is a measure of this rise. When there are no magnetomotive forces actually in the path of the pole,

$$\text{P. D.} = \int_o^l F \,.\, dl = \int_o^R N \,.\, d\,R,$$

The latter of these expressions arising from our conceptions of magnetic flux N_1, magnetic resistance R, and potential difference P. D.

But when M.M.F.'s occur in this path,

$$\text{P. D.} = -\Sigma m + \int_o^R N \,.\, d\,R,$$

where Σm = sum of M.M.F.'s.

$$\therefore \text{P. D.} = -\Sigma m + \int_o^R N \,.\, d\,\frac{l}{\mu\,A} = -\Sigma m + \int_o^l \mu\, B\, d\,\frac{l}{\mu}.$$

And if the pole is carried once round the circuit, since P. D. = 0, the effective M.M.F. can be measured either as the line integral of the magnetic force once round the circuit; or as a function of the intensity of magnetic induction, the permeability, and the length of the magnetic circuit.

The symmetry between the expression for the two circuits is remarkable and suggestive:—

$$\int_o^l \frac{l}{k}\,\Delta \,.\, d\,\frac{l}{k};\ \text{(electric circuit).}$$

$$\int_o^l \frac{l}{\mu}\,B \,.\, d\,\frac{l}{\mu};\ \text{(magnetic circuit).}$$

Many things of practical importance are suggested by this very close analogy. In the first place we can obtain from these integrals two very symmetrical expressions for force in the circuit; viz.:

and,

$$F = \frac{\Delta}{k};\ \text{in the electric circuit,}$$

$$F = \frac{B}{\mu};\ \text{in the magnetic circuit.}$$

This indicates the fallacy of confounding "lines of induction" with force; and of calling the former "lines of force," except when they pass through a portion of the circuit of unit permeability. There is a growing tendency to speak of "lines of force in the iron" when magnetic induction is intended.

In the second place, there is a very strong suggestion of the practical possibility of a set of magnetic units resembling those for the electric circuit. In matters electrical, when we had learned about the "line integral of the electric force," we straightway forsook it for the more practical ohm and volt and ampere. This could, and probably should, be done in the case of the magnetic circuit. A practical set of units, with convenient names, would be a great boon. The two complex functions, hysteresis and saturation, render this more difficult for magnetic "conductors"; but with a set of simple constants this difficulty can in great measure be overcome. As calculations are usually conducted at the present time, much unnecessary complication arises from the use of so many constants; these chiefly being caused by the use of a mixture of C.-G.-S. French and English measures. In Tables I. and II. these constants are reduced to a single constant for English measure; as this has been found greatly to shorten calculations for magnetic circuits.

K_1 = number of ampere-turns per foot length of magnetic conductor.
K_2 = magnetic resistance (C.-G.-S.) of one foot length and one square inch section.

Thus, to determine the number of ampere-turns required on account of a portion of the circuit L feet in length, the formula is simply

$$\text{ampere-turns} = K_1 \,.\, L,$$

and to determine the magnetic resistance of any portion

$$R = K_2 \,.\, \frac{L}{A},$$

where A is the sectional area in square inches; L being in feet as before.

For air, the constants, on the same system, are

$$K_1 = 3{\cdot}760\ B;$$
$$K_2 = 4{\cdot}7245.$$

Table I.—*Constants for Wrought Iron.*

B in C.-G.-S. lines per square inch.	Ampere-turns.	Magnetic Resistance.
	K_1	K_2
30,000	44·9	0·00188
35,000	52·9	0·00189
40,000	60·8	0·00191
45,000	67·7	0·0 0194
50,000	78·4	0·00197
55,000	89·0	0·00203
60,000	102·0	0·00214
65,000	122·0	0·00236
70,000	149·0	0·00268
75,000	184 0	0·0 0309
80,000	233·0	0·00366
85,000	309·0	0·00457
90,000	398·0	0·00555
95,000	576·0	0·00762
100,000	874·0	0·0110
105,000	1119·0	0·0134
110,000	2491·0	0·0285
115,000	4197·0	0·0458
120,000	7519·0	0·0787
125,000	10929·0	0·1098

Table II—*Constants for Cast Iron.*

B in C.-G.-S. lines per square inch.	Ampere-turns.	Magnetic Resistance.
	K_1	K_2
25,000	111	0·00562
30,000	183	0·0 0787
35,000	343	0·0123
40,000	617	0·0194
45,000	980	0·0274
50,000	1773	0 0446
55,000	2521	0·0576
60,000	3580	0·0 7:6
65,000	4699	0·0 908
70,000	7593	0·124
75,000	12816	0·215

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STENO-TELEGRAPHY.*

Under the name of steno-telegraphy, M. G. A. Cassagnes designates a new telegraphic system founded on the combination of mechanical stenography with telegraphy. This system can be applied indifferently to any stenographic machine worked by a key-board; but, as the inventor had specially in view Michela's stenographic machine, which he successfully adapted to the apparatus which has been experimented with on the French telegraphic lines, it is to this special application that the present notice refers.

Michela's stenographic machine is exceedingly simple in construction and extremely ingenious in principle. By means of 20 signs and their combinations, Michela's machine can represent all possible phonetic sounds constituting any language. As soon as spoken, the words are, so to say, decomposed by the ear of the operator at the key-board; the graphic representation of syllables is printed in small distinct lines on a tape of paper, and there only remains afterwards to read these lines from left to right to reproduce the language spoken, whatever it be. With Michela's machine, a skilled operator can stenograph 200 words per minute in a language with which he is familiar. This is more than is wanted to follow the fastest speeches; the number of words pronounced by the best known orators of the various countries vary from 80 to 180 per minute, giving an average of 130.

The aim that M. Cassagnes had in view was to reproduce at a distant station the stenographic tape that Michela's machine produces *in loco*, and at the same speed. To obtain steno-telegraphy, it is sufficient to place at each of the two distant stations one of the two principal constituents of the stenographic machine; the keys and the printing styles. The keys are placed at the transmitting station, and the styles at the receiving station. If a single-line wire is used it is necessary that the key-board should only be employed as a multiple contact key, and special apparatus be used to receive and distribute the electric currents. To transmit currents coming from several contacts to corresponding receiving apparatus by means of a single-line wire, one of the most satisfactory solutions consists in the use of a system of synchronous distributing and receiving apparatus.

The diagrammatic arrangement of the steno-telegraphic system is as follows:—Figs. 1 and 2 represent respectively the transmitting and the receiving stations. The key-board of the manipulating apparatus, placed at the transmitting station (Fig. 1), consists of 20 keys, C C, provided with contact pieces alternately connected with the positive and negative poles of a battery, P P', the middle of which is put to earth. The keys are also connected with the contact segments of a distributing commutator D. A brush F, fixed on the spindle of a soft iron toothed wheel A, is kept in a state of continuous rotation. This brush, as it passes successively over each segment, makes the connection between this segment and the line L L. At the receiving station (Fig. 2) a similar distributing commutator D', having a brush F' rotating in perfect synchronism with that of the transmitting station, has its contact segments in connection with polarised relays R_3, R_4, R_5.....R_{20}. It is thus easily seen that the currents sent on the line by the depression of the keys of the board, are received, at the other station, in the coils of these polarised relays, that they will act on their armatures and close the circuits of a local battery P'_3. The current from this battery will work the styles of the printing apparatus corresponding to the keys depressed at the transmitting station. When the stenographic signs corresponding to the depressed keys have been printed on the tape of the receiving apparatus, the tape is moved forward so as to allow of the printing of a new line of signs, and so on. There is thus obtained, by means of a single-line wire, the exact reproduction of the tape as heretofore described. The printing apparatus I (Fig. 2) contains 20 styles on which are engraved the stenographic signs corresponding to the 20 keys of the board. Each of these styles can be pressed against the paper tape by the armature of a corresponding electromagnet; the coils of the 20-electromagnets e, e, e are connected at one end with the binding screw V and at the other with the abutting contact screws v_1, v_2, v_3, &c., of the relays.

The system having been thus described in its chief parts, let us now examine in detail the series of currents and of corresponding motions which follow the depression of any combination of keys on the board. A stenographic line is produced by the depression of a certain number of keys (12 at the maximum). Suppose, for instance, that the three keys 3, 4, and 6 are depressed. When the brush F arrives on contact 3, F' is on contact 3'; a current travels along the line and throws the armature of the relay R_3 on the abutting contact screw; the circuit of the battery P'_3 is closed,

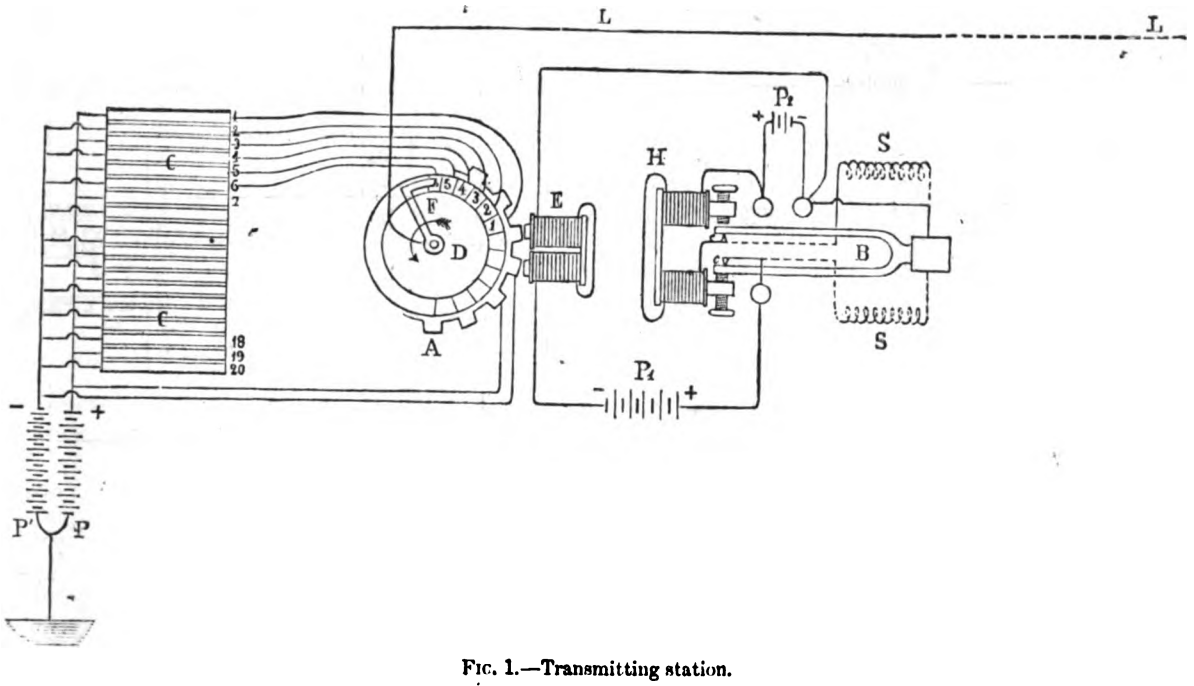

FIG. 1.—Transmitting station.

through the electromagnet e_3, and the style p_3 prints its sign on the paper tape stored at G and passing over the styles. The moment after, the brushes arrive on contacts 4 and 4', then on 6 and 6'. The battery P'_3 is successively closed through e_4, e_6, and the styles p_4, p_6 are thrown up against the paper tape which remains at rest during the printing of the stenographic line. The printing of the line is then finished; the combination of keys which have been depressed is reproduced on the paper.

The relays are brought back to their position of rest by local currents. When the last relay of the combination has been brought back, the circuit of battery P'_3 is open, and at this instant, the armature of an electro-magnet M, which is also in this circuit, is released, and the paper moves forward for another line. The system has now come back to the starting point, and a new combination of depressed keys, on a second turn of the brushes, will give rise to a second stenographic line. After each current the line is put to earth by the brushes themselves.

In order to obtain these results by means of a single wire, there can be employed any system capable of rotating the two brushes F and F' on the two commutators D and D' in perfect synchronism, and of correcting the variations which from one cause or another, arises in the speed of these brushes. The system made use of by M. Cassagnes is the synchronism by means of the phonic wheel of M. Paul La Cour, of Copenhagen. The system (Figs. 1 and 2) consists in an electro tuning-fork, B, the vibrations of which are kept up by the intermittent passage of the current of a constant battery, P_2, in the coils of the electro-magnet H. The interrup-

* From a pamphlet by M. L. H. Despeissis.

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tions are produced by the very vibrations of the tuning-fork, which close and open a contact at the extremity of one of the prongs. The vibrations of the other prong are utilised to send interrupted currents from battery P_1, in the coils of the electro-magnet E, the soft iron cores of which are thus alternately magnetised and demagnetised. In order to prevent the extra current-sparks between the prongs of the tuning-fork and the contact points, two high resistance shunts, S S, are placed between them. Opposite the poles of electro-magnet, E, is placed a soft iron wheel, A, with teeth on its circumference, and on the spindle of which is mounted a box-wood reservoir full of mercury, acting as a fly-wheel. On the prolongation of the spindle is also fixed the brush F, which rubs on the contacts of the commutator D. If the wheel is first rotated by hand at a certain speed, it will continue in motion on account of the successive attractions which the teeth undergo at their passage near the poles of the electro-magnet E. The wheel will thus rotate at a speed determined by the frequency of the tuning-fork and the number of teeth on its circumference. This speed will be therefore practically constant.

The receiving station consists of a set of similar apparatus; and it is easily understood that, if both wheels have the same number of teeth and the frequencies of the tuning-forks have been adjusted to be nearly the same, the two speeds will be very approximately equal. In order to render them rigorously identical, M. La Cour makes use of the following device: The commutator of the transmitting station is provided with two special contact segments, one of which is connected to the positive, and the other to the negative pole of the line battery. At the corresponding position of the receiving commutator (Fig. 2) is placed a single contact in connection with the coils of a polarised relay *r*. The wheels once put in motion and their speeds not being exactly the same, after a certain time the brush F will pass one of the two correcting contact segments of the transmitting station when F′ passes on the correcting contact of the receiving station. At that moment, a positive or a negative current will pass in the relay *r* according as F is on one or the other of the transmitting correcting contacts. This current will throw the armature of the relay *r* on one side or the other, and will introduce or cut off an adjustable resistance from the circuit of the battery P'_2. There will, therefore, be more or less current flowing through the electro-magnet H′, and the tuning-fork B′ will vibrate a little quicker or a little more slowly, according to the case, so that it will always be maintained at a mean speed equal to that of B. The two wheels will therefore always rotate at the same number of revolutions, and, at every instant, the two brushes F and F′ will always be on corresponding contacts of the two commutators.

Such is, in principle, the action of the apparatus in its simplest form. But, to make it practically serviceable, M. Cassagnes has been led to numerous modifications, either in the details of the commutators of the phonic wheels, so as to adapt them to the special object he had in view, or in the electrical connections so as to increase the output. We cannot enter into the detail of all these items, and can only point out some of the most important. Instead of having 20 contact segments distributed round the whole circumference of the commutators, they can be supposed grouped in sectors, the same commutator carrying two or three sectors of 20 contacts each, for instance. In this way, the formation and the transmission of a stenographic line can be repeated twice or three times in a turn, either by means of a single keyboard, the keys of which are connected to two or three different contacts, or by having independent key-boards connected each to the contact of a separate sector. Another simplification has arisen from the fact that certain keys are never combined together, and therefore certain pairs of keys can be connected to one and the same contact segment on the commutator. As these are always neighbouring keys that do not combine one with the other, one of them is made to transmit positive and the other negative currents; and, at the receiving station, the corresponding contact is connected with two relays oppositely polarised. The number of contacts can thus be reduced to 12 for each sector, and, the brushes rotating at the same angular speed and the number of sectors being the same, this allows of a greater duration in sending the currents.

The following are some of the experiments to which the steno-telegraphic apparatus has been submitted. In the first series of experiments the transmitting and receiving apparatus were placed alongside, in the same room of the Ministry of Telegraphs, 103, Rue de Grenelle, Saint-Germain. The two earths were different, and the up and down wires were on different posts.

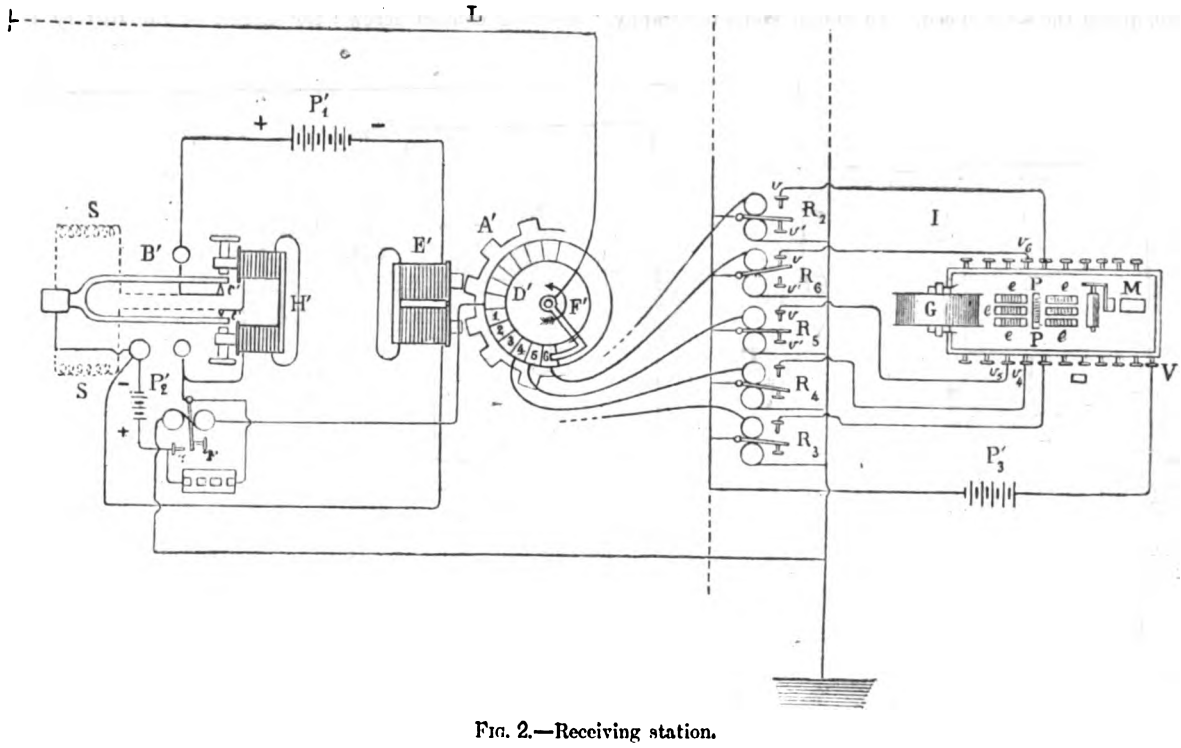

FIG. 2.—Receiving station.

Experiment, October 29th: Paris, Orleans and back. Circuit of 245 kilometres, out of which 19 kilometres underground. Resistance of circuit 2,000 ohms. Battery, 60 Callaud. Experiment, October 31st: Paris, Tours and back. Circuit of 480 kilometres, 35 underground. Earth at Asnières. Resistance, 3,100 ohms. Battery, 100 Callaud.

In the second series of experiments the transmitting apparatus was at Lille and the receiver at the Ministry of Telegraphs, rue de Grenelle. Experiment, January 19th: Half speed; Paris-Lille. Underground wire of 282 kilometres. Resistance, from 1,500 to 1,600 ohms. Experiment, January 20th: Paris-Lille, *viâ* Châlons, Bar-le-Duc, Nancy, Longuyon, Mézières, 770 kilometres, out of which 210 in 5mm. wire and 560 in 4mm. Resistance, about 6,900 ohms. The results of this second set of experiments were most successful, and the output of the steno-telegraphic apparatus proved to be very much greater than that of existing French telegraphs.

We have stated that, during each turn, the commutator with two sectors, for instance, allowed the transmission of two stenographic lines, corresponding to about 280 words per minute. But, on the other hand, an operator at the key-board can only work at the rate of 200 words. It would thus have been necessary to make use of two key-boards, and no contacts should be lost by the operators who would have to manipulate in turn and rhythmically. In reality, this is hardly possible, and an operator able to steno-

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graph 200 words per minute on an ordinary key-board can only, when thus hampered by the rhythm, transmit a much lesser number. This naturally brings us to mention the recent improvements made by M. Cassagnes. These improvements consist in the adjunction to the steno-telegraphic system just described—and which is of the nature of *multiplex* telegraphy—of a mechanical perforator and of an electrical transmitter which gives it also the character of *automatic* telegraphy. Through the use of a perforator, the key-board no longer gives direct electric contacts, but produces mechanically a perforated tape on which the signs are represented by holes at their respective places. The perforating key-board standing thus quite

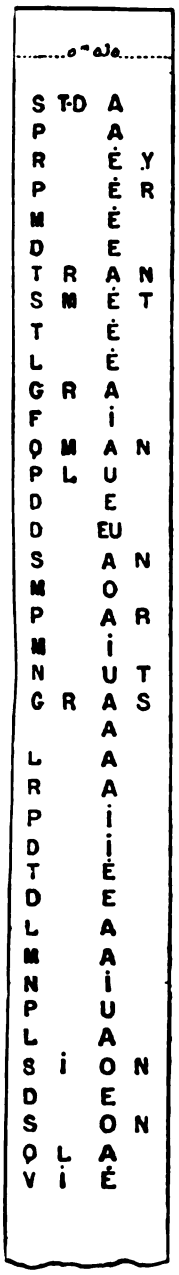

FIG. 4.—Slip produced by receiving instrument.

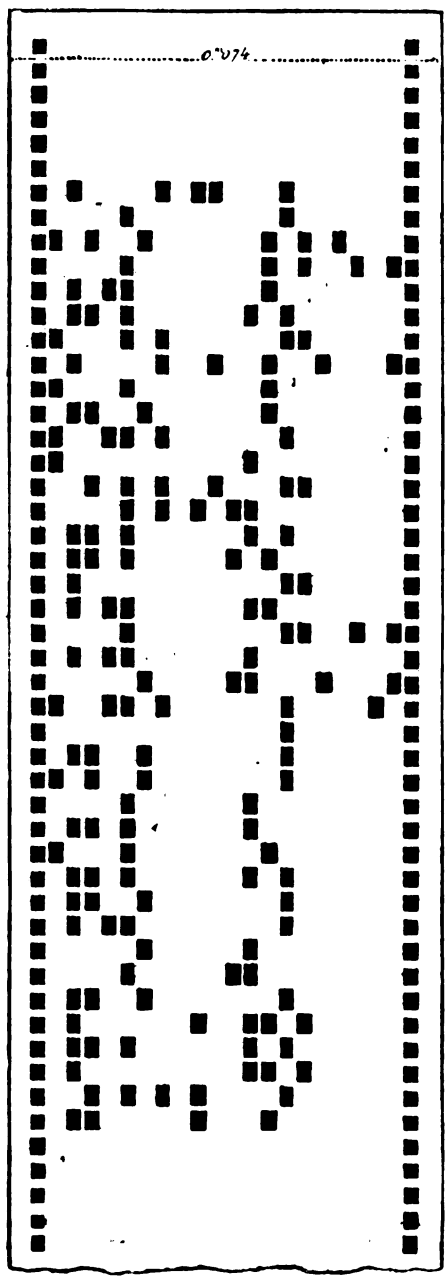

FIG. 3. Perforated slip.

independent of the rest of the steno-telegraphic system, the tape can be perforated at any speed, as when a correspondence is being copied or a speech stenographed. The perforated tape is then put in the transmitter and passed through at a speed regulated by the motion of the transmitting brush on its commutator. A set of springs successively establishes the contacts through the holes in each line of the perforated tape; and the currents, passing through the line wire and the relays, work the styles corresponding to the holes and print the stenographic signs on a line corresponding to that of the holes in the transmitting tape. The following speeds of transmission have been obtained by means of this automatic part of the system. 1. Up to 350 kilometres, 400 words per minute. 2. Up to 650 kilometres, 285 words per minute. 3. Up to 900 kilometres, 200 words per minute.

These numbers give the theoretical result, implying that there is no stoppage in the preparation of the tapes and their passage through the transmitter. It is also well understood that each sector can be used equally well for transmitting or for receiving, and that the above number of words represent those simultaneously sent in both directions, according to the wants of both stations.

Ordinarily phonetic orthography is employed; but, if desirable, grammatical orthography can be used, although, of course, at the cost of considerable reduction in speed. In Figs. 3 and 4 are shown respectively a perforated slip, and the corresponding slip of the receiver.

ELECTRIC LIGHTING IN THE TROPICS.*

BY W. H. FLEMING.

One of the chief difficulties that an engineer experiences who is called upon to instal a plant of any considerable size in tropical countries is the trouble of procuring any skilled labour for this particular class of work. Another difficulty is that he is so far from his base of operations—the factory—which will often lead him to depend upon himself in overcoming obstacles that arise from time to time as the work progresses. Language and the heat, as well as fevers, are minor affairs.

Electric lighting has already gained many warm adherents both in the East and West Indies, more especially in the former, where plants of considerable capacity have been in active operation for the past eight years. It is especially adapted for use in houses in warm climates, such as that of India, where the old-fashioned "punkah" is in daily and nightly use for cooling the rooms, accompanied with its attendant noise, as the "punkah wallah," a servant, pulls it backward and forward, causing the continual flickering of the lamps or gas. That system will, in time, I hope, give place to the noiseless motor fans and steady incandescents, thus enabling the Anglo-Indian to read and rest in comfort.

A central station plant that the writer was engaged upon lately in one of the chief cities of the West Indies would compare favourably in size and equipment with one situated in a city of a corresponding number of inhabitants in the United States. Alternating-current dynamos of a capacity of 4,500 16 candle-power lamps were employed for lighting the chief stores, theatres, and private houses, and 600 arc lights of 1,200 candle-power each lighted up the main streets and parks. It was at first intended to run a small plant in connection with the existing gasworks, more as an experiment than with a view to actual financial success; but in the space of six months the station was more than trebled from its original capacity. The people took to it from the start, paying cheerfully the prices that were demanded. To an indolent race it was a great boon. Money to them, it would appear, was of less account than the trouble and work called upon to go around and light up the different oil and gas lamps, since all the lights were switched on the different circuits at sunset. In the tropics, as is well known, there is no twilight. Darkness comes on within ten minutes of sundown, and the whole plant practically goes into operation at once.

The construction work on this particular plant was necessarily somewhat slow, as men unaccustomed to erect a 30 or 45 foot pole took their time to do so, in which operation they received the appreciation of the usual army of idlers. Poles suitable for carrying a number of circuits had to be imported from the United States, as well as the ornamental wooden columns for supporting the lamps in the parks and public squares. Poles of native growth could not be found straight enough, and even if of sufficient length were weak. Some poles could have been had from a tree called the ironwood tree. This wood, however, is of so close a grain and so very heavy that it was out of the question to use it. Many of the business streets were not more than from 20 to 30ft. across, including the sidewalks. Moreover, as curtains or awnings are stretched overhead from side to side by the owners of the stores to shelter and protect their goods from the sun's rays, it was impossible to erect a pole line down these streets. I found it better to run a 2in. iron piping up to the side of the houses every 150ft. to a point 6ft. above the coping stone, and then attaching to the top of this pipe a T, inserting in this T wooden cross arms, to which the insulators were attached in the usual manner. It must be borne in mind that the houses are not of very great height. Where this arrangement was impracticable, owing to the varying heights of the houses, I inserted strong iron brackets in the buildings, set in with cement and well painted with rust-proof paint.

* Read before the General Meeting of the American Institute of Electrical Engineers, Boston, Mass., May 21, 1890.

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In India considerable care has to be exercised in putting up a pole-line. If you want your work to stand any length of time, the base of the poles for one-sixth of their length must be thoroughly well creosoted, to resist, as far as possible, the ravages of an insect, called the white ant, or "termite." These insects live on wood. They attack even the woodwork of the houses, and soon reduce the thickest timber to a mere shell. They live in trees and construct nests of great size, like small sugar casks, made of particles of gnawed wood, and cemented by a kind of gluten. They are so strongly attached to the branches that they cannot be shaken down even by violent storms. It is a good plan to paint the poles eight feet above the surface of the ground with good gas tar if obtainable. In these climates special attention should be given to protecting the working parts of arc lamps, owing to the fact that rain occurs only for about three months of the year; and to make up for this loss, the humidity of the atmosphere is remarkable. It is not at all infrequent to find early in the morning the bottom carbon holders full of water, unless provision is made for draining this off. During the hot season a breeze springs up between nine and ten o'clock in the morning, and the ground being dry, the dust is terrific. Insects of a large size—much more so than those found in the northern climates—bats and small birds attracted by the glare are found either in the globes or lying at the base of the lamp posts in large quantities every morning; and the wholesale slaughter that takes place nightly seems to have no effect in diminishing these pests. It was found better, therefore, on the arc service to give a man about 25 lamps to trim and clean per day; and the native entrusted with this work was held responsible, and if the lamps were found in a dirty condition he was fined, which usually had a good effect.

In the construction of station buildings one is guided much by the facilities for procuring stone, brick, or other suitable material in that particular locality. Galvanised iron is sometimes used for roofing, but more frequently roofs are constructed of a sun-baked clay tile, provision being made as is usual for an ordinary wire tower for distributing the various circuits. A point to be noted is that the engineer should construct his rain gutters for taking off the storm water at least double the size that is ordinarily allowed for temperate climates. Roofs and the outsides of the buildings are whitewashed.

To give an idea of the heat from the sun, I may mention that I had to replace considerable quantities of insulated wire after it had been up only a short time, the insulation in places sagging right away from the copper wire and finally dropping off. During the rainy season prevailing in the West Indies in the months of June, July, and August, and in the East Indies known by the name of the south-west monsoon, and prevailing from May to the latter part of August, electrical storms occur almost daily. They are often exceptional in violence, and much trouble and anxiety arise from possible damage to line, lamps, and dynamos, even though protected by good lightning arresters.

While a heavy storm was in progress one night last summer in the West Indies, I noticed when in the station a curious effect of a flash, that fused the lead strips on an ordinary saw-tooth arrester connected with one of the incandescent circuits. The strips were entirely destroyed or volatilised, and what was before a polished plate of brass, was now tarnished with a film of the lead vapour; and there was distinctly marked, as if photographed on the plate, a zig-zag streak, in all appearance like a photograph that had been taken of lightning. Engineers, during the prevailing season of storms, should take particular pains that their lines and machines are thoroughly well protected, and that the arresters have good earth connections.

A sad case came under my notice that happened at a temporary installation for illuminating a camp in Poonah, in the Bombay Presidency, with arc lamps in honour of a visit of an influential rajah. While the festivities were taking place in the evening, a heavy storm occurred. Lightning entered on the line—no provision had been made for diverting its course—and it destroyed the dynamo, besides killing the native oiler who just at that moment was engaged in filling up the oil cups on the bearings. He was either thrown or fell across the commutator end of the dynamo, as he was found in that position, his hands much burnt as well as his feet.

In the year 1877 the first commercial arc lamp was in use at the offices of the Bombay *Times*, and if I remember correctly it was the first light shown in the Indian Empire. From that date on the demand for lighting has been on the increase; but pretty nearly all the work has been confined to isolated work and small central stations, cotton mills, sugar and indigo plantations, Government buildings and large private dwelling houses. Places of business and offices do not require lighting, as business is conducted by the merchants only from seven o'clock in the morning till four in the afternoon. The inhabitants of hot climates necessarily spend much of their time out of doors and are fond of social gaiety. They have been famous for centuries for skill in illuminating; and this fact has added much to the popularity of arc and incandescent lamps, which, as is well known, particularly lend themselves to artistic illuminating purposes. From this knowledge, in the early part of 1885, I imagined that it would be a financial success to get together a travelling portable electric light plant, consisting of a vertical boiler, engine, and two dynamos, one an 8-arc light machine and the other a 100-light incandescent, both mounted on a stout frame which rested on a pair of trucks. This work was carried out, and I was kept actively employed for many months in going round to different large Indian estates and native palaces for the fêtes that attend the various religious and family ceremonies that the wealthy natives are fond of indulging in. Large sums of money are spent, and the festivities often last for a week or longer. It turned out to be, as I surmised it would, a regular "bonanza," until on one occasion in bringing the unwieldy contrivance down a steep hill, on one side of which was a ravine, it fell over; and it is needless to relate that the whole apparatus was seriously damaged. I found it would not pay to patch it up again, so, after stripping everything that was portable, I left the remainder to lie and rust in the tropical vegetation.

Owing to the high price of coal, which is a costly article in the tropics, ranging from $8 to $50 per ton delivered, it is well to employ the most efficient and economical engine for motive power, more especially for central-station work. In the station previously referred to we were running with high-speed compound condensing engines with satisfactory results. In many sugar plantations in the West Indies where the installations are of a comparatively small size, economy in this direction is not practised, as the amount of steam used is not missed, the boiler capacity on estates ranging from 100 horse-power to one at Cienfuegos, Cuba, of 2,500 horse-power. It behoves the engineer, however, who has charge of a plant to exercise considerable care and watchfulness over his native firemen. The natives as a rule, I have found, if treated with kindness and forbearance, show an aptitude in learning and taking hold that is often remarkable, more so than with some of their brethren of a lighter colour, who, because they have been taught how to start and stop a dynamo, or trim an arc lamp, give themselves all the airs of an expert in electrical matters, and have got beyond that stage when they are willing to be instructed, or to be obedient to orders—an unwillingness that sometimes leads to disastrous results.

The types of machines chiefly in use in the East Indies are those of English and French manufacturers, Siemens, Gramme, Silvertown and other well-known types. Those in use in the West Indies and South and Central America are generally of American make, and the market is not a small one. The great strides that both the foreign and home companies have made in the last two or three years in the supply and equipment of electrical plants for these distant lands, are very evident signs that this particular business is receiving great attention at the hands of local merchants, planters, and city or town officials, and that they are more and more influenced by the many advantages to be gained by the use of electric lighting. Planters find now that it is much to their gain in a financial way. In former years, for example, the facilities of shipping their produce were restricted, and the work was done in daylight and slowly. Now with weekly and almost daily sailings, it has become an absolute necessity that they should get their produce ready with the quickest despatch possible, and this they do by the aid of the electric light.

When an engineer is called upon to instal or take charge of an electric light plant, it will be well for him to insist pretty closely not only that all the materials specified in the estimates have been shipped, but that every class of tool requisite for constructional work is included. Much time is lost and much trouble is made when you find that your outfit does not include "climbing spurs" or draw vises and other important articles. I have known engineers who have had expensive testing sets, Wheatstone bridges, reflecting galvanometers and other delicate instruments sent out with them, and then found that they had few or any tools to work with, and that the nearest hardware store was many miles away through a rough country; and even then, the store when reached did not contain the requisite goods, there having been no stock kept because there was no demand made for them. Spare armatures, complete sets of arc lamp apparatus, as well as duplicate parts of dynamos, spare brasses and gear for engines and tubes for boilers, should always be included, and it should be seen that they are shipped.

Apart from the vicissitudes incidental to life in the tropics, there is, I think, always a satisfaction and pleasure in the successful completion of an installation, knowing as one does that it is a potent factor in the greater civilisation of those countries, demonstrating to the inhabitants, who have heretofore depended on artificial illumination of the same primitive character and manner as their forefathers used through ages past, what science, aided by her lieutenants, "pluck and energy," can accomplish.

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THE LANE FOX PATENTS.

A meeting was held at the offices of the Lane Fox Electrical Company on the 1st inst.; Mr. Cobden Saunderson in the chair. Among those who were present were Mr. St. G. Lane Fox, Mr. C. A. Stephenson, Mr. W. Grove, Mr. Sidney Morse, Mr. B. Drake, Mr. R. S. Erskine, Mr. C. F. Cooper (Messrs. Paterson and Cooper), Mr. F. Gripper (Messrs. Edmundson), Mr. Stepney Rawson, and Mr. A. P. Trotter.

The CHAIRMAN commenced by a *résumé* of the situation of the patents of Mr. Lane Fox. These patents had been transferred to the British Electric Light Company, who did nothing with them, and whose business was transferred to the Anglo-American Brush Company. This Company was principally interested in arc lighting, and did not bring incandescent lighting to the front, as they wished to push their arc lighting specialities. As soon as the numerous sub-companies were formed, a complicated tangle of litigation followed, and it was impossible to take any proceedings to work the patents. It was not until late last year, when the litigation between the Anglo-American Brush Company and the Edison Swan Company was concluded, that the patents were ultimately transferred to Mr. Lane Fox, the two companies reserving its licences. The Lane Fox Company was then formed. The patents, as patents, were in abeyance for several years; but the system described by the patents was adopted generally wherever incandescent lighting has been used. The object of the Company was to be paid for the use of the system. The Chairman then referred to the published reports and opinions of various authorities, and an analysis of the patents of Mr. Lane Fox and of Mr. Edison, and to circulars which had been sent to the trade making offers as to royalties. Several different methods were suggested. For undertaking companies it was proposed to make a charge based on the Board of Trade units supplied to consumers. For private installations the charge would be based on the number of lamps; 1s. 6d. per 16 candle-power lamp being charged for private houses, and 2s 6d. for public buildings, such as clubs, hotels, offices, &c. It was suggested that contractors might collect the royalties from the customers who had bought plant from them, and if the contractor negotiated such payment a discount of 10 per cent. would be allowed to the contractor. In conclusion, he invited discussion, criticism, advice, and co-operation in whatever was found to be reasonable.

Mr. C. F. COOPER asked for information as to what kind of installations were meant?

To which the CHAIRMAN replied: All which include the use of accumulators which involve the patent.

Mr. COOPER asked what was claimed.

Mr. LANE FOX: The patent covers the system of constant potential where accumulators are used. At the date of the patent the idea of constant potential was unknown. He had had many arguments with Mr. Preece, Sir W. Siemens, Mr. Spottiswoode, and others; and at that time the idea was inconceivable to them. They all thought that the current would go by the shortest course through the first lamp. They could not conceive the idea that the mains would offer a very small resistance. The Edison system, which was said to embody the discovery of practical distribution of the electric light, turned out to be merely a method of regulating lamps arranged in series. He spoke always of "the current."

Mr. COOPER: Does not the patent assume that there was no method of regulating, such as we have in the compound machine?

Mr. LANE FOX: The patent assumes no machine.

Mr. COOPER: In many small installations, accumulators are not used, there is simply a compound machine.

Mr. LANE FOX: I described the idea of a shunt for regulating, but I do not now claim it, and where regulation is achieved by other means we do not claim it.

Mr. COOPER: Where there is a small plant, in which you charge the accumulators in the morning, and you leave them to run the lamps at night, do you claim that?

Mr. LANE FOX: Certainly; there are broad claims in the patent, but they are narrowed down to batteries by the disclaimers.

Mr. COOPER: The Patent 3,988**, as it stands at the present moment, appears to describe accumulators acting as regulators while the dynamo is going—is not that merely as a regulator?

Mr. LANE FOX: It is stated "The supply will be available after." A regulator and a reservoir are the same thing. At first, the exactly opposite view was taken, and it was suggested that it referred only to an installation where the lamps vary in number.

Mr. STEPNEY RAWSON: In 1883 it was said that batteries would not act as regulators. Will there be no claim for royalties where no accumulators are used?

The CHAIRMAN: No, that is disclaimed. It is only where accumulators are used as regulators or as reservoirs.

Mr. GRIPPER: You do not claim parallel distribution only, or the use of accumulators, but the combination?

The CHAIRMAN: That is so.

The question of the validity of the patent being raised,

Mr. SIDNEY MORSE said that they could not settle the validity of the patent at this meeting.

Mr. A. CAMPBELL SWINTON presumed that they might pay a small royalty if they had little doubt, and pay more if they had a great doubt.

Mr. SIDNEY MORSE: Certainly, you should pay nothing if you do not believe in the validity of the patent.

Mr. SWINTON asked how the opinions which had been republished had been obtained—some appeared to be statutory declarations, and began without any preamble.

Mr. LANE FOX replied that they were given in the action against the Edison Company by the Brush Company. The result was a compromise. The case was for the use of parallel distribution at the Athenæum Club, in 1886.

Mr. SWINTON said that he had been given to understand that one gentleman repudiated the construction which had been put upon his statement.

The CHAIRMAN: We put no construction.

In reply to an invitation for some suggestions,

Mr. COOPER said that it was not a sufficiently representative meeting to enable anything to be settled. He reserved anything he had to say, he merely came to learn.

Mr. GRIPPER said that he too had only come for information.

Mr. SWINTON asked whether, in a case where there was a large number of lamps, and a small accumulator capable of supplying only a few of them, the royalty would be charged for the lamps.

The CHAIRMAN replied that an attempt had been made to meet different cases by different methods.

Mr. ERSKINE pointed out that, if a charge was made on the revenue of a central station, part of the revenue goes to the buildings and engines, and these had nothing to do with the patent.

Mr. SIDNEY MORSE: You might shave your revenue down to nothing in that way. Buildings and such charges occur in all businesses.

Mr. ERSKINE: Under those conditions we would rather not put up such plant.

Mr. SIDNEY MORSE: But does not this come, in your case, to only £300 a year,—only $\frac{1}{10}$th of the maximum charge per unit for two years?

Mr. LANE FOX: Special terms are offered to those who will come to an arrangement now. We do not pledge ourselves to make the same terms hereafter to the rest of the trade.

Mr. SWINTON: Do you expect the consumers to pay? Do you count on having a remedy against the consumer, or against the contractor?

Mr. SIDNEY MORSE: Both.

Mr. SWINTON: Does not this offering of a discount amount to a bribe?

Mr. SIDNEY MORSE: Such discounts are common in any selling transaction.

After a general discussion, during which no definite offer was made or entertained, the meeting separated.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 20, 1890.

The Halpin-Savage Torpedo Boat.—This electric automobile torpedo boat seems to be reaching a stage at which its general adoption by the Governments of the world is probable. Its main peculiarity as distinguished from other vessels of the sort is an arrangement by which the torpedo is fired from the boat after it has come in contact with the netting surrounding a vessel, and is fired downward, being retained by a chain, so that its course is semicircular, and it thus explodes directly under or alongside of the vessel attacked. The boat is submerged near the surface of the water, and is guided by incandescent lights, which show from the rear only. The boat is driven by storage batteries, and carries with it five miles of wire for guiding purposes. The screw propeller makes as many as 2,000 revolutions per minute, and gives the boat considerable speed. It is in many respects an advance upon anything that we have had upon this side of the water thus far.

Electric Traction for Railways.—The electrical engineers of America having, as they believe, conquered the street horse-car, and feeling confident of their victory over the cable-road as well, are turning serious attention to the problem of applying electricity to regular railroad work, and have previously noticed the splendid researches of Mr. O. T. Crosby in this direction, and other investigations, showing the direction in which the problem is gradually developing. Dr. Louis Bell, the editor of *The Electrical World*, read before the Scranton Science Club last evening a long and elaborate Paper upon the history of electrical traction in general, confining himself in the main to that part of the work which has already been done, and is firmly established in electrical history. His lecture was therefore mainly interesting to electricians because it gave the flat-footed opinion of so eminent an authority that electric traction is certain in the near future to replace the steam locomotive. Dr. Bell said:—"I do not hesitate to say, and I say it deliberately, that to operate an ordinary railroad train by an electric locomotive is a far simpler problem electrically and mechanically than the operation of street cars under ordinary conditions of City traffic. The slow speed necessary for street cars is a disadvantage in that it

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compels us to gear down the motor. In running at railway speed no such difficulty is encountered, and the obnoxious gearing may be dispensed with entirely. Nor is there any practical difficulty in building motors large enough to do the work. I do not think there is a prominent electric company to-day that would hesitate to take an order for a 500 horse-power machine and guarantee its performance. I certainly know of several that would be glad of the chance, and would accomplish the task successfully. Neither is there any difficulty in conveying the current to any of these large motors moving at railway speeds. In other words, the question is simply one of economy. As to this, I consider it to have been absolutely demonstrated that electricity can profitably replace steam in this field. The principal advantage that we should gain by using electric motors supplied from a central station instead of the present steam locomotive would be a much more economical use of coal. This is due, of course, to the vastly superior efficiency of stationary compound engines as compared with the locomotive of to day or of any other day, and also to the fact that the electric motor does not have to carry with it its coal and water, and can be kept clean, which a locomotive cannot." Dr. Bell also pointed out the magnificent possibilities of economy in the use of water power along the many roads of this country that follow streams upon which hundreds of thousands of horse-power are constantly going to waste. This power by the adoption of electric railroading could be turned into available traction.

The Association of Railway Telegraph Superintendents.—This Association held its ninth annual meeting at Niagara Falls on June 18th and 19th. Papers were read by Robert Stewart, superintendent of the Central Railroad of New Jersey, on the "History and Development of the Block System." Mr. Stewart was the first to introduce this system in America, and has been foremost in the development of it in this country, and he gave a very complete account of all the different systems in use in this country, with a history of the development of each. Mr. Charles Selden read a Paper upon the "Increased Adhesion between the Wheels of the Locomotive and the Track caused by the Passage of a Current of Electricity." His conclusions followed those of Mr. Elias E. Ries, and Mr. Selden is firmly convinced that an important discovery has been made in this field which will increase the tractive power of locomotives by something like 25 per cent. Mr. Selden's statements, however, were questioned by Mr. Nicholls, whereupon a model motor and track were introduced to prove the assertions of Mr. Ries. The experiments made satisfied those present of the correctness of Mr. Selden's conclusions. Mr. W. F. Taylor followed with a Paper on "Lighting at Wrecks," and gave a description of the electric light car used by the Pennsylvania Railroad to illuminate the scenes of accidents and to facilitate clearing the track after trouble. Other Papers were—by Mr. B. Leonard, on "Electric Lighting in Railway Service;" by Mr. George C. Kinsman, on "Train Despatching, its Uses and Abuses;" and by Prof. H. S. Pritchatt, of Washington University, St. Louis, on "Correct Time and How shall we Maintain it."

CORRESPONDENCE.

PRIMARY BATTERIES FOR LIGHTING PURPOSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The article in your number of June 27th about primary batteries shows me that your paper sides with the majority in condemning primary batteries for lighting purposes. Let us look into the difficulties you raise, and see if they are really insuperable.

First, as to the cost—the all-important point. It is the fashion among electrical engineers of the day to say that primary batteries *must* dissolve or consume 20 grains of zinc per ampere-hour; and that, therefore, since zinc is more expensive than coal, primary batteries *must* be more expensive than steam-engines. To begin with, although something must be consumed to produce current by chemical means, it is by no means conclusively proved that that something need of necessity be zinc; neither has it been proved that zinc is the most economical thing that can be used. However, let us take it for granted that we must use zinc, merely for the sake of argument, and let us see what the consumption of zinc would cost, provided there was no waste. The market price of Silesian spelter, according to the *Economist* of June 27th, was £23 per ton; this works out at about 2½d. per pound. Upon this basis it would be calculating on the safe side to take zinc moulded to given sizes at 1s. per pound. Then 20 grains of zinc consumed to produce one ampere-hour of current, we get 384 ampere-hours of current for 1s., as far as the consumption of zinc is concerned. When we come to think that lamps of all tensions, from five volts upwards, are now being made to take but half an ampere of current, we can see that the consumption of zinc is not a very formidable item in the cost of working a primary battery, being about 1s. per day of seven hours for 100 lamps, taking half an ampere of current. Now as to the solution used, how much acid does it take to consume 20 grains of zinc? My answer is, that it takes comparatively little.

I think if we come to consider the reason why the thing has not been economical so far from a chemical point of view, we shall find that it is because too great an excess of acid is put into each cell at starting, and that therefore the action set up is more rapid than is necessary, giving rise to the evolution of an unnecessary amount of hydrogen gas and the consequent necessity for the introduction of a very powerful depolariser. Now let us investigate how far this point of the economy of a battery has so far been understood and compensated for.

So far primary batteries exist in two forms, namely, the single and the two fluid cell. What are the defects of both, and how can they be remedied? First take the case of the single-fluid cell; in this an active fluid is used to act upon the zinc, and as it is found that the cell polarises we introduce an oxidising agent which is supposed to take up the hydrogen formed. So it does, part of it; but a portion of the depolariser acts on the zinc forming more hydrogen, since it probably has a greater affinity for zinc than for hydrogen; and, therefore, it has been found that the action of a single-fluid cell is spasmodic, and that the only way to prevent the cell getting exhausted in a very short time is to perpetually refresh the solution, which entails the consumption of a very large quantity of solution and zinc. Next, let us take the case of the two-fluid cell. In this case we use a dilute solution to act upon the zinc, and a powerful depolariser surrounding the negative element separating the fluids by means of a porous division of some kind; here a better result can be expected, as the too rapid action of the depolariser is restrained by the porous division; but the mistake in this case is that the porous division is in itself a non-conductor of electricity, and the result of the cell is therefore limited by the internal resistance. A cell must therefore be invented which slowly supplies the depolarising fluid, and has at the same time a low internal resistance. This is not impossible, as I propose to show in a very short time.

The last difficulty which your article raises is the question of skilled labour. I flatter myself that my own or any other very ordinary human intellect is good enough to devise an arrangement to automatically supply a liquid at a given rate from a cistern filled once a week, month, or even a longer period, according to the size of cistern and amount of work required. In towns, this cistern could be mounted over a battery in a cellar under the pavement and supplied through a port in the pavement in the same sort of way as our coals are now, thus dispensing with any such phenomenal person as the domestic servant mentioned in your article. I think, if you consider the foregoing points, you will come to the conclusion that a primary battery fit for lighting purposes, though perhaps at present unknown and at first sight an impossible thing commercially, is still a possible thing. But I venture to say that it will be invented by a chemist, and not by a steam engineer converted into an electrician.

In conclusion, let me say that I wish I had the honour to be that man. It must also be borne in mind that the chemical was the first way of producing electricity, and I fancy it will finally triumph over steam.—Yours, &c., ELECTROMANIAC.

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LEGAL INTELLIGENCE.

Gorman v. Brighton and Hove Electric Light Company (Limited).

In the Queen's Bench Division of the High Court of Justice, on Saturday, the case of Gorman v. Brighton and Hove Electric Light Company was concluded before Mr. Justice Denman, Mr. Justice Charles, and Mr. Justice Vaughan Williams, sitting as a Divisional Court. This was a motion by the defendants for a new trial on the grounds of misreception of evidence, and that damages were excessive.

Mr. Pyke appeared for the defendants in support of the motion, while Mr. Chapman opposed it on behalf of the plaintiff.

Mr. PYKE, in supporting the motion, said the action was brought by the plaintiff, sueing for herself and six children, to recover damages for the loss of her husband. The husband, who was 32 years of age at the time of his death, was a night watchman in the employ of a brewery company at Brighton, and in receipt of 22s. per week. He was found dead on the roof of a house, having apparently been killed by an electric shock. The question of damages was tried before the Under-Sheriff and a jury, who awarded the plaintiff £800, being £200 for herself and £100 for each of the six children. He (the learned counsel) submitted that the amount of damages was excessive. On behalf of the plaintiff, an actuary was called to show that an annuity for a man in the position of the deceased for an amount representing what he earned would cost £1,090. He submitted that such evidence ought not to have been admitted, as it was not the proper basis for the jury to have assessed the damages upon. There were many contingencies to consider—the man might not have remained in continuous employment, and so on.

Mr. JUSTICE DENMAN said it seemed to him that the damages might be regarded as excessive in the case of the children rather than of the widow.

Mr. PYKE remarked that he had calculated that at the outside the jury should not award the widow more than £150, or give more than £50 each to the children, making in all £450.

Mr. JUSTICE DENMAN thought that the case was one that might be compromised. There had been an omission apparently to consider the position of the widow.

Mr. CHAPMAN said all the matters were left to the jury by the Under-Sheriff. As to a compromise, the difficulty was that his client had fixed a sum below which he could not go, and his learned friend could not assent to that.

Mr. JUSTICE DENMAN mentioned privately a sum which he and his learned brethren thought plaintiff ought to accept.

Mr. CHAPMAN said he could not accept the proposal until the solicitor had communicated with the plaintiff.

Subsequently Mr. CHAPMAN said he had received an intimation from his client that she was prepared to take £550, which was £50 in excess of the amount suggested by their lordships. The extra £50 was added to clear her of any possible costs that might arise between her and her solicitor.

Mr. PYKE said the defendants could not undertake to pay more than £500. Of course, if the jury had in the first place given that amount the plaintiff could not have asked for £50 for costs between her solicitor and herself. She had already had taxed costs.

Mr. JUSTICE DENMAN said the Court could not screw the defendants up to give the plaintiff more than £500, but they thought that the defendants should pay the costs of the motion for a new trial.

Mr. PYKE said the defendants were willing to do that.

The motion for a new trial was accordingly refused with costs, the damages being reduced to £500.

The Whitecross Company v. The Credit Lyonnais.

This case, which was recently tried before Mr. Justice Smith and a special jury, and resulted in a verdict for the plaintiffs for £1,446, was argued on Friday last before the Divisional Court, consisting of Justices Denman, Charles, and Vaughan Williams, on a motion for a new trial.

Mr. Gully, Q.C., and Mr. Abrahams represented the applicants; Mr. R. T. Reid, Q.C., and Mr. Hollams for the respondents.

The claim was for damages in relation to a contract entered into between the plaintiff Company and the Spanish Government for galvanised iron wire for telegraphic purposes, the allegation being that the defendants had undertaken to act as plaintiffs' agents in Madrid, and by their neglect allowed a firm of Hamilton and Co., through whom the contract was originally made, to obtain payment from the Spanish Government, which the said Hamilton and Co. did not hand over to the plaintiffs. The defendants alleged, on the contrary, that they only undertook to act as bankers, and were not responsible for the loss the plaintiffs had sustained.

Mr. JUSTICE DENMAN held that the judge at the trial was right in leaving the questions he did to the jury instead of interpreting the contract himself as a question of law, though this was not very material, as the finding of the jury was in accordance with the interpretation which the judge ought to have put upon the correspondence had he deemed it right to do so. Neither did he think the verdict could be attacked on the ground that the damages were excessive or too remote.

Mr. JUSTICE CHARLES concurred in the result, though he thought the question should not have been left to the jury.

Mr. JUSTICE WILLIAMS agreed entirely with Mr. Justice Denman.

The motion was dismissed with costs, but it was intimated that there would be a further appeal; execution was stayed for 14 days.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

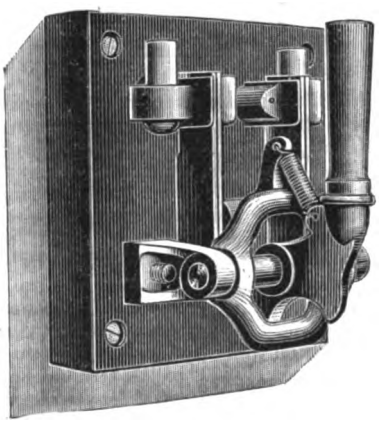
APPOINTMENTS VACANT.—The Guardians of the poor of the Fulham Union, having in contemplation the adoption of the electric light for the workhouse, infirmary, and other premises of the Union situate in the Fulham Palace-road, Hammersmith, announce that they will be glad to receive offers from practical engineers, thoroughly experienced in electric lighting, but totally unconnected with any particular company or system, who would be willing to survey the Union premises and advise the Guardians as to the best and cheapest way of carrying out the work they have in view. Full particulars will be found in our advertising columns.

FOR SALE.—Particulars are given on page xv. of advertisements of an electric light station to be disposed of by the Alliance and Dublin Gas Consumers' Company.

MESSRS. LAURENCE, SCOTT, AND CO. (LIMITED).—We are asked to notify that the style under which Messrs. Laurence, Paris, and Scott (Limited) has previously traded, has been altered to Laurence, Scott, and Co. (Limited).

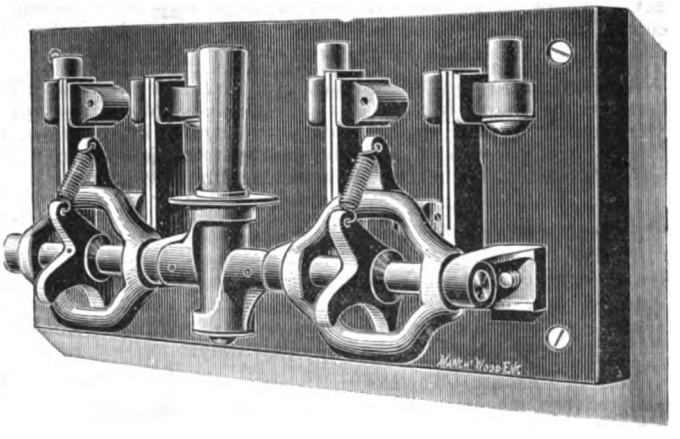
A NEW STORAGE BATTERY.—Messrs. Shippey Brothers have on view a new type of storage battery called the "Standard." It is specially constructed for traction purposes and boat propulsion. The elements are light in weight, and are easily handled; the plates, instead of being vertical as is usual, are placed horizontally, separated by china discs. At present only one size and type will be made, viz, 17 plate cells, 200 ampere-hour capacity; size, $6\frac{1}{2} \times 6 \times 11$. The inventors do not limit the rate of charge between 10 to 100 or even the discharge, provided the cell does not fall below 1·7.

MESSRS. DORMAN AND SMITH'S NEW SWITCH.—We illustrate a single-pole and a double-pole switch now being manufactured by



Single-Pole Switch.

Messrs. Dorman and Smith. These switches have a sudden release, double break, and large spring contact surfaces. They are strongly made, and, as will be seen by the illustrations, bear evidence of



Double-Pole Switch.

having originated in an engineer's shop. These switches are made in several sizes in both the single-pole and double-pole types.

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THE PAISTE SWITCH.—We illustrate below a novel form of switch, designed and patented by Mr. H. T. Paiste, of Philadelphia, U.S.A., for the manufacture and sale of which Mr. A. Reyrolle, of Union-mews, London, W., has recently secured the European rights. The switch has met with much success in America, where we are informed that not less than 100,000 are in use by the leading companies, including the Edison, Sawyer-Mann, Westinghouse, and Thomson-Houston. Many of the companies speak of the switch in terms of the highest praise. The following brief description will show the design of the switch:—Two plates (made from sheet brass), one U-shaped, the other being straight, are used. These are mounted on a base of non-conducting material. The binding screw on the U-shaped plate is the terminal of one circuit wire, and the screw on the straight plate the terminal of the other. Two arms, A and D, are hinged to a spindle, the bearing of which is located in the centre of the U-shaped plate. A spring joins the end of the two arms, and keeps the arm A pressing firmly against the straight plate, as well as the arm D against the U-shaped plate. The circuit is completed as the arm A joins the U-shaped plate, and the straight plate, through its spindle and the arm D, also at its point.

To break circuit the spindle is turned (by means of the handle screwed into its centre) to the right a quarter turn, by which motion the arm A slides along the straight plate (cleaning it) until B is reached (while the arm A is sliding along the straight plate it is lengthening the spring), at which point the straight plate becomes the tangent of a circle, of which the arm A (hinged on the spindle) becomes the radius. As soon as the straight plate becomes the tangent the arm A flies rapidly to C, when the circuit is broken. What arc-ing there is is on the back of the arm A, and not on the face, where electrical contact is made. The circuit is completed by a like movement, the arm D coming to rest at A. It is claimed by the inventor that each time the switch is used better contact is secured, as the arm seats itself in the straight plate, like a hammer blow. The switch is manufactured in various sizes, mounted on china, with cover and handle of same material.

MESSRS. SHAW AND CONNOLLY.—This firm are inviting tenders for the various works required in the erection of an electric cable manufactory at Newton Heath, as an extension to their present works.

ELMORE'S PATENT COPPER DEPOSITING COMPANY.—This Company have taken premises at 56, Queen Victoria-street, London, E.C., where they have on view a large display of seamless copper tubes and cylinders of all sizes up to 18 inches in diameter.

TECHNICAL AND GENERAL NEWS AGENCY.—We were in error last week in announcing that this agency was established to supply "cuttings." We understand that the agency has been formed to furnish "reliable and original matter only obtainable through the agency's own connections earlier than through other sources."

INTERNATIONAL EXHIBITION OF MINING AND METALLURGY.—This Exhibition is announced to be opened at the Crystal Palace on July 16th. The New South Wales Government have taken 15,000 feet of of space, and South Australia, Western Australia, Tasmania, New Zealand, Victoria, and Queensland, will be unofficially represented, and several foreign Governments will participate officially. The machinery hall will be lighted electrically.

POSTAL REFORM.—The Postmaster-General is reported to have adopted the suggestion that the public should be allowed to post circulars, price-lists, and other documents not being of the nature of a letter in open envelopes at the book post rate; and that the Postmaster-General has also recommended the Treasury to permit any person to provide and transmit through the inland post a card bearing a half-penny adhesive stamp, such card to be the same size as the present post-card.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

June 16, 1890.

9,261. E. T. HEADECH. London. A new or improved electric arc lamp.

9,263. J. DRUMMOND. Manchester. Improvements in electric cut-outs and switches or other circuit breakers (R. O. G. Drummond and D. A. Bremner, South Africa).

9,274. P. H. WILLIAMS. Surrey. Utilising the waste or other water power of rivers, canals, tides, &c., &c., for electrical or other purposes by constructing or erecting lock, shute or other weirs, with hollow iron piers and foundations or casings upon iron screw or ordinary piles, and filling with concrete, &c., to carry water wheels and encased dynamo water wheels of any kind, or by floating dynamos on such dynamo water wheels.

9,275. P. H. WILLIAMS. Egham. Constructing water wheels of any form, and providing or utilising space in the interior for enclosing or attaching dynamos of any kind, or attaching encased dynamos to water wheels of any kind or to their spindles or shafts, or floating dynamos.

9,284. W. H. SCOTT and LAURENCE, PARIS AND SCOTT (LIMITED). Norwich. Switches for making and breaking electric circuits.

9,289. C. E. NICHOLS. London. Improvements in electric motors.

June 17, 1890.

9330. W. H. DOWLAND and W. MILLS. London. Improvements in the electrolysis of chlorides, and apparatus therefor.

9343. R. M. HAGUE. Newbury. A new and improved flexible-jointed pipe for fluids, gases, &c., and for insulation of electric or other wires.

9357. A. BARKER. London. Improvements in switches for electric glow lamps.

9361. T. L. WILLSON. London. Improvements in electric reduction of metals, and in apparatus therefor.

9395. O. ROMANZE. Of and on behalf of the firm of Romanze and Weise and F. W. White, London. Improvements in electrical apparatus for the production of rotary motion.

June 18, 1890.

9,429. E. BAINES. Huddersfield. An improved insulator for telegraphic or other purposes.

June 20, 1890.

9,602. SIEMENS BROS. and Co., Limited. London. Improvements in the distribution of electrical energy (Siemens and Halske, Germany).

SPECIFICATIONS PUBLISHED.

1889.

8,973. BOSSHARDT (Verdier). Secondary batteries. (Price 8d.)
12,795. KENT. Arc lamps. (Price 8d.)
10,878. MORISON. Electric telephones. (Price 11d.)
10,910. HOLLINS. Electric couplings. (Price 8d.)
12,091. CLAMOND. Incandescent gas-burners. (Price 8d.)
12,444. SMITH. Telephone systems. (Price 8d.)
14,656. BERNSTEIN. Electric glow lamps. (Price 6d.)

1890.

3,544. PATTEN. Electric telegraphy. (Price 2s.)
4,087. CHESWRIGHT. Secondary voltaic batteries. (Price 6d.)
5,335. LAKE STETSON. Electrical conductors. (Price 8d.)
6,893. VON DER POPPENBURG. Incandescent light. (Price 4d.)

Fourth Edition.

3,880. JENSEN (Edison). Conductors for electricity. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

The West African Telegraph Company (Limited).

The fifth ordinary general meeting of the West African Telegraph Company (Limited) was held yesterday at Winchester House, 50, Old Broad-street, E.C.; Sir John Pender, K.C.M.G., presiding.

The SECRETARY (Mr. William Payton) read the notice convening the meeting and the minutes of the previous meeting, the latter being afterwards approved and signed as correctly entered.

The report of the Directors and statement of accounts (the former of which was given in our last issue) were taken as read.

The CHAIRMAN: Gentlemen, before I make any general remarks, I wish, as this is practically the second, or what I would call consolidating, meeting of this Company for the future, I should like to put before you a few figures, which will always be valuable to refer to at any future time. It will be seen on reference to the accounts in your hands that they have been arranged somewhat differently from those submitted in previous years. I think you will find the accounts in the new form to be

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clearer and more convenient. The alteration has necessitated the charging of several items under different headings from those shown in 1888. It would, therefore, be unsatisfactory to compare the individual items and show the net increases and decreases, more especially as we have considerably augmented several of the stations for the joint working arrangement with the South African and other Companies and the new cable between Bonny and Principé. I will, however, show you the net result of the year's working to December, 1889, as compared with the previous year. The gross revenue for the year ending December, 1889, amounted to £64,661, as against in 1888 £55,315, or an increase of £9,346. This increase is almost entirely derived from traffic exchanged with South Africa. Communication between this Company's line and Cape Town was established on June 4th, so that in the past year's accounts we have had the benefit of this new traffic for only seven months. As the South African traffic is worked under a joint purse agreement between the Eastern, the Eastern and South African, the Brazilian Submarine, the Spanish National, and this Company, as long as the communication is maintained by either coast of Africa, our revenues are secured. The amount brought forward from last account amounted to £4,878. 4s. 8d., against in 1888 £1,215. 9s. 11d., or an increase of £3,662. 14s. 9d. The total expenses for 1889 amounted to £21,155. 9s. 8d., in 1888 £20,016. 0s. 7d., increase £1,139. 9s. 1d. This is almost entirely due to the causes just mentioned. The hire of cable-repairing ships, £1,780. 3s. 1d., is charged in the current revenue account, and the balance of preliminary expenses, £750, is written off. A fair amount has been written off for depreciation of cable stock. The net result of 1888, after providing for expenses, interest, and sinking fund for the redemption of the Five per Cent. Debentures, was a dividend at the rate of 2½ per cent. per annum ; £5,000 to repairs and renewals account, and £4,878. 4s. 8d. carried forward. This time we declare a dividend at the rate of 5 per cent. for the year, charge repairs and renewals to revenue account, and carry to general reserve fund the sum of £16,145. 11s. The balance standing to the credit of repairs and renewals account, £3,074. 2s. 5d., has been carried to general reserve fund, so that with interest on investments added, the general reserve fund amounts to £19,712. 18s., which, as will be seen from abstract C of the accounts, is fully invested in first-class securities.

Now, gentlemen, that puts your accounts in a very satisfactory position, and I think it redeems every promise that I made to you when I had the pleasure of addressing you twelve months ago. At the first meeting in 1887 there was no dividend at all, in 1888 we paid 1½ per cent., and in 1889, when the Board was reconstructed, the dividend was 2½ per cent. That was when I addressed you last, and I said that the combination that was formed led me to believe that the result would be a very considerable increase in the dividend of this Company ; that we should tap to some extent the Cape traffic, and that the joint purse formed would be such as to give this Company a fair proportion of that traffic. The outcome has been that we shall declare to-day a dividend of 5 per cent., as against 2½ last year. I may say, further, that this Company is, as I foreshadowed, on the rails, running a very favourable race alongside the other submarine companies, and I believe will play a very important part in the future of submarine telegraphy. If the Dark Continent is to be opened up we shall be prepared to lead, or to follow, as it may be, in the interests of those who open up that country. At all events we are ahead as pioneers, and we are prepared to do our part in that important development. I may mention, with regard to the Conference which has just been held at Paris, of all the submarine cable companies and all the land line companies of the different countries, that the result has been, I believe, that the cable companies hold a higher position to-day in the scale of telegraphic communication than they have ever done at any period of their history. It will be the pride of the Chairmen of all these respective companies to maintain that position. We stand high in the estimation of the public because we do our work well, and we stand well with the European Governments because they appreciate the work which we do. We are, on the whole, fairly treated ; yet at the same time the tendency is always towards reductions of rates, and we have to take our part in these reductions as well as the Governments. It must not be forgotten, however, that reductions very often lead to increased traffic ; and I hope whenever a reduction is made by any one Conference that the telegraphing public will so take advantage of it that by the time another comes round we shall recoup ourselves any loss that may be sustained. With these remarks I beg to move :—

"That the report and accounts for the year ended December 31, 1889, submitted to this meeting be, and they are hereby, received and adopted, and that a dividend be declared payable on and after this date of 6s. 6d. per share, free of income-tax, making with the interim dividend already paid, a total distribution for the year of 5 per cent."

Sir JAMES ANDERSON seconded the motion.

Mr. S. W. KORLLE said that it appeared from the prospectus that they had two subsidies—one of £42,000 and another of £12,000. What was the reason that the amount figured in the accounts at only £43,000 odd ?

The CHAIRMAN : The Portuguese is a guarantee—the French subsidy is a practical subsidy. The Portuguese undertake to make up a certain number of words which they pay upon, and that is more or less a fluctuating figure. It is a very courageous thing on the part of the Portuguese Government to guarantee a very large traffic of that kind, and, if that traffic should grow, to wipe out the guarantee altogether, which would show that the Company was depending upon trade traffic rather than upon Government protection.

The resolution was carried unanimously.

Sir JAMES ANDERSON moved and Sir HENRY MANCE seconded :

"That Sir John Pender, K.C.M.G., and Robert Kaye Gray, Esq., be, and they are, hereby, re-elected Directors of the Company."

The motion was carried unanimously

The CHAIRMAN : I am very much obliged to you for the honour of re-electing me to my seat on the Board of this Company. I am extremely pleased to see that we have laid a good solid foundation, and that year by year we have every reason to believe we shall erect upon that foundation a very handsome structure. The fact of myself and Mr. Robert Kaye Gray sitting on the same Board is good evidence of what I call union among telegraph companies ; and, as we all know, union is strength. I am very pleased to sit at the same table as Mr. Gray in promoting what we have at heart, the advancement of submarine telegraphy.

The CHAIRMAN next moved, and Sir HENRY MANCE seconded,

"That the appointment of John Denison Pender, Esq., as a Director of the Company be, and it is hereby, confirmed."

The auditors, Messrs. Deloitte, Dever, Griffiths, and Co., having been re-elected,

A cordial vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN, in returning thanks, said that he believed that the Board, as at present constituted, embraced all the elements which ought to make the Company a success. They were all men experienced in submarine cable work, and would be able to make this new Company a strong link in the great chain of the submarine telegraph system.

The proceedings then terminated.

The Electrical Engineering Company of Ireland.

The first statutory meeting of this Company was held on Saturday last at the office of the Company, Dawson-street, Dublin ; Sir Howard Grubb, F.R.S., presiding.

Mr. A. A. DAVIS, secretary of the Company, read the notice convening the meeting.

The CHAIRMAN said : This meeting has been called in conformity with the Limited Liabilities Companies Act, which requires a meeting to be held within four months of the date of registration. The Company was registered on March 5, 1890. The prospectuses were issued to the public on the 8th, and as a result 6,800 £2 shares were allotted to the public and vendors. At this early period of our existence, I suppose I will not be expected to make any detailed statements as to the work done by, or the future prospects of, the Company. I may mention, however, that although we can hardly be supposed to have fairly started and have not as yet got to work in the new premises which we have secured, and which we hope you will approve of, we have obtained some good contracts ; and the great number of estimates which we have been asked to furnish not only give good promise for the future, but show very clearly that the establishment of such a Company as this has become a necessity in Dublin. It must be remembered, however, that while there is little doubt that electric lighting will in time find its way into extensive use in this city, there are many causes which just at present check its development. The acceptance of many of the estimates applied for has been made contingent on the starting of the general electric lighting scheme proposed by the Corporation of Dublin, and it would appear that the arrangements for this are not yet quite complete, and the period within which it will be available for the general public is therefore uncertain. If the Corporation scheme be carried through without delay there will be much work to be done immediately. On the other hand, if no such scheme was contemplated, many business houses would be prepared to erect private installations ; but so long as this matter remains uncertain, we cannot expect intending users to lay out money on private installations which may become in part unnecessary on the establishment of a general lighting scheme. Again, the public require to be further educated as to the advantage of electric lighting. Up to the present the question which users invariably asked was simply—will my gas or my electric light bill be the heavier at the end of the year ? There are, however, I think, signs that the time is coming when in comparing the relative advantages of the systems the public will learn to place the doctors' bills, deterioration of furniture, decorations, books, &c., on the right side of the account ; and perhaps by that time we shall be getting a little tired of the oft-repeated story of the electrically frizzled horse which crops up so opportunely in the local papers whenever any electric light scheme is mooted, the scene of the cremation being laid sufficiently remote to ensure immunity from any very searching investigation. I have spoken of the deterioration of gilding, books, &c.; and perhaps I may be allowed to mention one specific case which has come under my own immediate ken. In an institution not far from where we are sitting, and in which I frequently have business, I happen to know that a sum of £50 was added to the decorator's estimates for the purpose of doing some gilding to the ceiling and cornices of one particular room. Judging by the effect already produced, though the gas is seldom used in that room, this will not last for many years, whereas if electric light were in use it would be good for fifty years. Also I understand that a considerable sum of money will have shortly to be expended in the rebinding of books, the backs of which have been completely destroyed by the products of the gas. In this particular case it would certainly have been much cheaper to use electric light than gas, even if the latter were supplied without any charge whatever. Again, electric light installations have, as every one is aware, been frequently undertaken by firms wholly without the required technical knowledge or the means of obtaining it, the result being that the work has been done in an inefficient manner, which often brings discredit not only on the particular firm which executed the order, but on the electric lighting industry in general. In our Company, as you are aware, there is no mixing up of electric light with any other business. We have in our employment an efficient staff of electrical engineers, all of whom have held positions under some of the largest and best known electric light companies now working, in addition to which, in case of any work of great magnitude, we have the advantage of the experience of

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one of the oldest, largest, and most successful electric lighting companies in the world—viz., the Brush Corporation of London. Another check which has operated strongly against the rapid development of electric light is that the temptation in the case of inexperienced firms has been very strong, particularly when there is much competition, to promise too much and to cut down the estimates as closely as possible to secure the order. Your Board do not believe in the wisdom of endangering the future reputation of the Company for good, honest, and lasting work for the sake of a possibly increased show of work in the present; and while endeavouring to execute orders with as much economy as is consistent with the best results, they do not propose to undertake work (for advertising or other such purposes) which will not pay a reasonable profit. I am happy to be able to state that the estimates which we have already furnished have been drawn up on these lines. The matter of agencies in provincial towns to represent the Company has engaged the attention of your Board, and advertisements are being inserted in various papers inviting application for same. In conclusion, the Chairman pointed out the advantages to health from the use of electric light instead of gas, and stated that since the installation of electric light in the Post Office, there had been a saving of £600 a year effected, owing to the decrease of leave of absence to the members of the staff who were ill.

Mr. HASLAM proposed, and Mr. NICHOLSON seconded, the election of Sir H. Grubb, George F. Fitzgerald, Thomas J. Haslam, Emile Garcke, David Sherlock, and J. H. North, as Directors.

The motion was passed unanimously.

Mr. J. H. NORTH proposed, and Mr. WILSON seconded, the election of Sir Howard Grubb as Chairman of the Company, which was unanimously adopted.

Mr. HARRISON proposed that a sum of £200 per annum be set apart as the remuneration for the Directors other than the Managing Director, which was unanimously adopted.

Messrs. Harrison and Nichols were elected auditors to the Company.

A SHAREHOLDER asked why the contract for the lighting of the new Science and Art Museum had not been obtained by the Company.

The CHAIRMAN said the contract had been closed before the Company was incorporated.

Mr. EMILE GARCKE, secretary of the Brush Electrical Engineering Company, London, was moved to the vice-chair, and a vote of thanks was passed unanimously to Sir Howard Grubb for presiding.

Sir HOWARD GRUBB having responded, the proceedings terminated.

National Telephone Company (Limited).

Report of the Directors for the year ended April 30, 1890, to be presented to the shareholders at the tenth ordinary general meeting of the Company, to be held at the City Terminus Hotel, Cannon-street, London, on Friday, July 11, 1890, at 12 o'clock noon.

The Directors have the pleasure of submitting to the shareholders the accounts for the year ended April 30, 1890, showing a balance to the credit of net revenue account of £183,375. 19s. 7d., after providing for the amalgamation expenses and the accrued interest on the Debentures and new shares. Of this amount the sum of £66,131. 5s. has been absorbed by the payment of an interim dividend on the Preference and ordinary shares at the rate of 6 per cent. per annum for the first six months of the year. The Directors propose to pay a further dividend on both classes of shares at the rate of 6 per cent. per annum for the last half of the year, which will absorb a further sum of £66,131. 5s., and leave a balance still on hand of £51,113. 9s. 7d. In view of the near expiration of the Company's patents, the Directors think it prudent to strengthen the reserve account, and they propose, under Article 113 of the Articles of Association, to transfer to this account £40,000, leaving £11,113. 9s. 7d. to be carried forward to next year.

The extension of the Company's business during the past year has been very satisfactory, the gross annual rental from exchange, trunk, and private lines having increased from £343,544. 1s. 1d. on April 30, 1889 (prior to the amalgamation), to £392,541. 19s. 1d. on April 30, 1890, an increase in the year of £48,997. 18s.

The important trunk lines connecting London with the principal towns in the Lancashire, Yorkshire, and Midland districts, were completed as far as Edgware in January last, and the service proved to be perfectly clear and distinct. Some difficulty was then experienced in running the wires through to London, which was not overcome in time to have the connection completed before the issue of this report. The Directors have every confidence that the communication between London and the north will be established by the end of this month. A large number of additional trunk lines connecting various towns in the provinces have also been commenced during the year, many of which have been completed. These trunk lines supply a much felt public want, and will add greatly to the strength of the Company.

The Directors believe it most important to continue the policy of developing and improving the Company's system, and of giving greater facilities to the public. The capital required for this purpose the Directors propose to raise by the issue of Debenture Stock or Preference Shares, as may be found best for the interests of the Company.

The accrued rental for the year ended April 30, 1890, was £364,704. 17s. 5d., an increase of £45,162 over the accrued rentals for the National, United, and Lancashire and Cheshire Companies for the year before the amalgamation. The working expenses for the year ended April 30, 1890, amount to £148,457. 0s. 9d., being 40·7 per cent. on the accrued rental, whilst the working expenses of the three companies before the amalgamation were 47·7 per cent. This saving of 7 per cent. is owing to reductions of working expenditure rendered possible by the amalgamation.

The Directors have taken over the business of the Northern District Telephone Company (Limited), which is now merged in this Company.

The Postmaster-General not having given notice to purchase the Company's business under the power reserved by the terms of his licence, is not now entitled to do so for another period of seven years.

The auditors, Messrs. Welton, Jones, and Co., retire and are eligible for re-election.

NEW COMPANIES REGISTERED.

BAXTER'S (LIMITED).—Objects: To carry on business as general, mechanical, manufacturing, civil, marine, and electrical engineers and metal founders, and purchase or acquire businesses of such character. Capital, £20,000, in £5 shares. Registered, June 16th. Frederick U. Baxter, Director. Offices, Sandiacre, Derby.

BEALE'S (LIMITED).—This Company has been registered with a capital of £75,000, in £1 shares, to acquire the business of a public caterer, restaurateur, general provision dealer, licensed victualler, and electric light and power contractor, now carried on under the style of W. Beale and Co., at 370, 372, and 464, Holloway-road, N.

ARTHUR DASHWOOD AND SONS (LIMITED).—Registered, with a capital of £10,000 in £1 shares, to purchase the business of E. H. Dashwood, engineer, 28 and 29, St. Swithin's-lane, London, E.C., and Wimbledon, Surrey.

EDINBURGH ELECTRIC SUPPLY CORPORATION.—This Company has been formed to carry on either in Edinburgh or elsewhere the business of electric lighting, and to produce and supply electricity or electrical currents and forces, and also to provide and supply, wholly or in part, by means of electricity or electrical currents or forces, light, heat, motive

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SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
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power, or forces, or telegraphic, telephonic, or other means of communication. Nominal capital £100,000, in 20,000 shares of £5 each.

HEAD, WRIGHTSON, AND CO. (LIMITED).—Objects: To take over as a going concern the business of Charles Arthur Head and Thomas Wrightson, manufacturing and civil engineers, at South Stockton, Yorkshire, and at 5, Victoria-street, Westminster, Middlesex, under the style of Head, Wrightson, and Company, adopting therefor an agreement with the said parties, the terms and conditions of which are not specified in the articles of association. Capital £210,000, in £5 shares.

INTERNATIONAL OKONITE COMPANY (LIMITED).—This Company was registered on 24th ult., with a capital of £340,000, divided into 17,000 Ordinary and 17,000 Preference shares of £10 each, together with £100,000 Six per Cent. Debentures, to adopt an agreement (unregistered) with Woodhouse and Rawson United (Limited), and to manufacture and sell insulated and other electric wires and cables for telegraphic, telephonic, and other purposes. The number of Directors is not to exceed six resident in the United Kingdom, and five in the United States of America; the first Directors in the United Kingdom are to be appointed by the subscribers; the first American Directors are F. Cazenove Jones, H. Durant Cheever, W. L. Candee, J. H. Cheever, and H. Martin; qualification for subsequent Directors, 50 shares or £500 stock; remuneration of British Directors, £1,500 per annum, divisible, and in addition 3 per cent. on all net profits other than those made by the American branch of the business; the Directors in the United States are to be called the committee of management in America, and they will be entitled to 5 per cent. of the net profits of the American branch. Solicitors, Messrs. Parker, Garrett, and Parker, St. Michael's Rectory, Cornhill.

MUNTZ'S METAL COMPANY (LIMITED).—Registered with a capital of £300,000 in £5 shares, to acquire Muntz's Metal Company (Limited) (in liquidation), and to carry on the business of manufacturers and dealers in copper, &c.

THETFORD ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—Objects: To carry on the business of electricians and generally to supply electric light and power at Thetford and surrounding district. Capital, £5,000 in £10 shares. Subscribers of one share each are:—G. Burrell, jun., engineer; R. G. Burrell, engineer; F. S. Burrell, engineer, all of Thetford; W. Jackson, Knottingley, Yorks.; and J. Houchen, solicitor; F. V. Houchen, solicitor; and T. Lumley, engineer, all of Thetford. First Directors (two to four) the four first above-named subscribers. Qualification, £50 in shares or stock. Remuneration to be determined in general meeting. Registered June 23rd. Registered offices, St. Nicholas-street, Thetford, Norfolk.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended June 27th amounted to £4,169, as compared with £3,156 in the corresponding period of last year.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of June were £3,300, as compared with £3,397 in the corresponding month of last year. The receipts for the month of March, estimated at £4,000, realised £4,018.

EASTERN TELEGRAPH COMPANY.—This Company announce that, subject to final audit, the accounts show, after placing about £120,000 to the reserve fund, a balance available sufficient to pay at the general meeting, on 17th July inst., the fixed dividend of 3s. per share, being at the rate of 6 per cent. per annum on the Preference shares, less income-tax; and a final payment of 2s. 6d. per share, with a bonus of 3s. per share, both free of income-tax, on the Ordinary shares, making, with previous payments on account, a total distribution of 6½ per cent. on those shares for the year ended March 31, 1890. The transfer books of the Company will be closed from the 10th to 17th July, both days inclusive.—The traffic receipts of this Company for the month of June amounted to £51,019, as against £44,805 for the corresponding period of 1889, or an increase of £6,214.

HALIFAX AND BERMUDAS CABLE COMPANY (LIMITED).—Coupon No. 2 on the Debentures of this Company is now payable by Messrs. Dimsdale and Co., 50, Cornhill, E.C.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).—An interim dividend for the quarter ended March 31st last of 2s. 6d. per share has been declared by the Board, payable on the 15th inst.—The traffic receipts of this Company for the month of June amounted to £43,198, as against £39,350 for the corresponding period of 1889, showing an increase of £3,848.—This Company notifies that the coupon on the Five per Cent. Australian Government Subsidy Debentures, due on July 1, will be paid on and after that date, by Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C.

INTERNATIONAL OKONITE COMPANY (LIMITED).—The prospectus of this Company was issued early this week, and announces that the Company is formed to undertake the manufacture of insulated telegraph, telephone, and other electric wires and cables. The share capital is £340,000, in 17,000 Preference shares and 17,000 ordinary shares of £10 each, in addition to 1,000 Six per Cent. Debentures of £100 each, equal to another £100,000. These debentures are a first charge on the entire undertaking, and are to be redeemed on July 1, 1910, at par, and a dividend of 8 per cent. is to be paid on the Preference shares. The consulting engineers to the Company are Sir William Thomson and Dr. John Hopkinson. In addition to taking over the large business done in America by the Okonite Company, this Company also absorbs that of Messrs. Shaw and Connolly. We must refer our readers to the prospectus for an account of the business now being done by these firms, and for particulars of the somewhat roseate outlook for the future anticipated by the promoters. The list of applications was opened on Tuesday last and closed on Wednesday. Messrs. Woodhouse and Rawson are the promoters of the venture, and must have great confidence in the undertaking to leave the subscription lists open for so short a time.

MAXIM-WESTON ELECTRIC COMPANY (LIMITED).—A meeting of this Company was held on Wednesday last at Winchester House, Old Broad-street, "to discuss the position of the Company." The meeting was private, and our representative was refused admittance. We understand, however, that the shareholders are to be asked to subscribe a further sum of £3,000 to enable the Directors to carry on the business of the Company. The Chairman (Mr. Blades Gooding) expressed his belief that there was a very fair prospect of their Company being able to do a profitable trade in view of the present extended use of the electric light, and of the inevitable demand for the light on an economical scale. A discussion followed, generally of a favourable character, and several of the shareholders present offered to subscribe further money. It was suggested that an appeal should be made to the shareholders, and an issue of debentures on a small scale was recommended.

OBITUARY.—The death occurred on Sunday last of Mr. Francis Bennoch, a gentleman who was well known in City circles, and was one of the Directors of the Venezula Telephone and Electrical Appliance Company.

STOCK EXCHANGE.—Application has been made to the Committee to allow the Commercial Cable Company $7,216,000 capital stock to be quoted in the official list.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month ended June 30, 1890, amounted to £5,475.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts of this Company for the half-month ended June 30th show an increase of £353 as compared with the corresponding period of last year.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended June 27, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,216, as compared with £2,017 in the corresponding period of last year.

WESTERN COUNTIES TELEPHONE COMPANY (LIMITED).—An extraordinary general meeting of this Company was held at the offices, High-street, Bristol, on Friday last, when the resolution, passed at the extraordinary general meeting held on May 30th last, was confirmed as a special resolution. It effects several alterations in the Articles of Association rendered necessary by the amalgamation of the National and United Telephone Companies, and substitutes the name of the former for that of the latter throughout.

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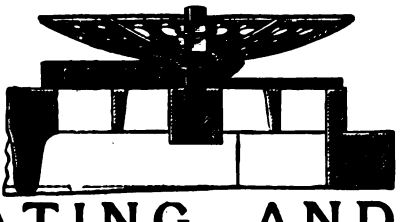

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"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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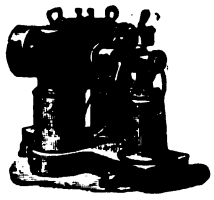
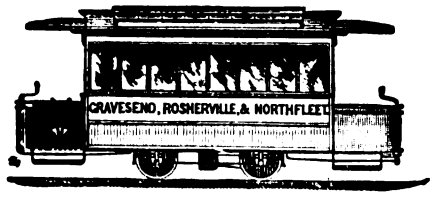
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, June 25.		Price Wednesday, July 2.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 2.	
										Highest.	Low
£			**TELEGRAPHS.**					£ s. d.			
1,381,390	Stock	12/6	Anglo-American	50	51	50	51	5 17 10	Jan., Apr., July, Oct	51	..
2,809,310	Stock	25/0	Do. Preferred	86	87	86	87	5 14 11	" "	87	86⅞
2,809,310	Stock	..	Do. Deferred	14⅜	15⅛	14¼	15	..	.. ..	14⅞	..
250,000	£100	4%	African Direct, 4 per Cent. Debentures xd	99	102	97	100	4 0 0	January and July ..	100	99½
130,000	10	3/0	Brazilian Submarine xd	11⅜	12¼	11⅜	12	6 2 5	Mar., June, Oct., Dec.	12	..
69,200	100	5%	Do. 5 per Cent. Bonds	101	103	101	103	4 17 1	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series) xd	106	109	103	107	4 7 10	June and December	..	..
..	$100	..	Commercial Cables	104½	104⅝	104½	104⅝	..	.. ..	..	..
16,000	£10	9/0	Cuba Submarine	12	12½	12	12½	7 4 0	February and August	12½	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3⅜	4½	3	4	5 3 6	March & September	3½	3
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October ..	..	..
60,710	20	3/6	Direct United States	10⅛	10⅝	10⅛	10⅝	6 14 11	Jan., Apr., July, Oct.	10⅝	..
400,000	10	2/6	Eastern	14	14½	14	14½	4 11 3	" "	14⅝	14
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15½	15½
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	14½	14⅝	14½	14⅝	4 16 7	Jan.. Apr., July, Oct.	14⅝	13½
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101	103	101	103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 per Cent. (Austin. Gov. Sub.) Debs. 1900 xd	104	107	103	106	4 7 4	January and July ..	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 xd	102	105	100	103	4 12 3	" "	..	..
180,227	10	2/0	Globe Telegraph and Trust	8⅞	9⅛	9	9¼	5 9 7	Jan., Apr., July, Oct.	9¼	9⅛
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 18 8	" "	15½	15⅛
150,000	10	5/0	Great Northern xd	15⅞	16¼	15⅞	16¼	4 12 4	Jan., July, and April	16¼	15½
15,000	100	5%	Do. 5 per Cent. Debentures, 1881 xd	102	106	100	103	4 17 1	January and July ..	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	37	39	37	39	6 8 2	April and October ..	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	108	..
9,000	8	6/0	Reuter's	7⅜	8⅛	7⅜	8⅛	6 1 3	April and October..	..	..
3,331	£100 Cert.	..	Submarine Cables Trust	112	116	112	116	..	" "	..	115½
15,609	£10	5%	West African	9⅜	10⅛	9⅜	10⅛	4 10 11	.. ..	10	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	101	..
30,000	10	2/0	West Coast of America	6⅛	7	6	6¼	8 11 5	January and July ..	6⅜	..
150,000	100	8%	Do. Debentures 8% xd	111	116	108	112	6 11 0	June and December	..	..
388,321	10	Nil.	West India and Panama	2⅜	2⅜	2⅜	2⅜	..	.. ..	2⅜	..
34,563	10	6/0	Do. 1st Preference 6%	11	11¼	11	11¼	5 4 4	April and October..	11¼	11⅛
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12⅛	13⅛	12⅛	13⅛	..	.. ..	..	..
64,572	15	6/0	Western and Brazilian	10	10⅛	10	10⅛	5 14 4	May and November	10⅛	10
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	..	..	6⅞	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3⅞	4	3⅞	4	..	..	3⅞	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	.. ..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	104½	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	122	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5½	Consolidated Telephone Const. and Maintenance..	⅛	⅝	⅛	⅝	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼	⅜	¼	⅜	4 8 3	Yearly	..	..
386,875	5	3/0	National	5⅛	5⅜	5⅛	5⅜	..	June and December	5⅛	5⅛
49,825	5	1/4½	Do. New	5	5⅛	5⅛	5⅜	..	.. ..	5⅜	5⅛
15,000	10	..	Do. 6 per Cent. Cumulative 1st Preference..	12⅛	13	12⅛	13	4 12 4	June and December	13	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference..	10⅛	10⅜	10⅛	10⅜	..	" "	..	..
209,750	1	..	South of England, Ordinary	¼	..	¼	..	..	.. ..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	3	3½	2⅜	3½	..	.. ..	..	..
55,000	5	2/0	United River Plate	4½	5	4⅜	5	..	January and July ..	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock xd	90	94	90	94	5 6 5	.. ..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures xd	..		..		..	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅛	2⅜	2⅛	2⅜	..	.. ..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	5⅛	5⅜	4⅜	5⅛	..	.. ..	..	..
42,853	5	..	Westminster Electric Supply	1⅜	2⅛	1⅜	2	..	.. ..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅛	2⅛	2⅛	2⅛	..	..	2⅜	..
63,416	2	1/2	Do. Preference	1⅞	2	1⅞	2	..	..	1⅞	1⅞
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5⅛	5⅜	5⅛	5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..		..		..	..	..	..
409,000	10	..	Electric Construction	9⅜	10⅛	9⅜	10⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5⅛	6⅛	5⅛	6	..	..	5⅛	5⅞
20,000	5	..	Fowler-Waring Cables	2⅛	2⅜	2	2⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works..	19	20	19	20	5 0 0	February & August	..	..
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	.. ..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5⅛	5⅜	5⅛	5⅜	3 13 0	..	5⅜	5⅛
37,350	12	36/0	Telegraph Construction and Maintenance	44	46	44	46	5 3 11	March and July.....	45⅛	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894 xd	101	104	100	102	4 8 8	.. ..	..	..





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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

From the answers given in the House of Commons by Mr. Raikes, and in the House of Lords by the Earl of Jersey, with regard to the Government's decision not to purchase the telephone companies' interests, we may reasonably infer that, instead of buying up the business outright, the Post Office authorities rely upon its falling into their hands sooner or later on their own terms, or by process of natural selection. Competition is talked of when the patents expire next year; and it would seem that the chief competitor will be the Post Office itself. This is a rather serious outlook for the patentees, especially as they have not been able, or, perhaps, not particularly anxious, to win over public sympathy on behalf of their exclusive monopoly. The principal company may have some ground of complaint against the Government; but, so far as the public are concerned, we believe they will contemplate with profound indifference any action that may be taken to put the telephone administration—at all events, that of the metropolis—into different hands. What the Directors may think of the prospect now before them will probably be made known at the National Telephone Company's meeting on Friday; and we must reserve further comment until next week.

There are hardly enough data in the account of Dr. Paul Schoop's gelatinous accumulator, which we publish to-day, to enable a fair comparison to be made between this ingenious invention and an ordinary secondary battery with dilute sulphuric acid. One would expect to find a high resistance, and a sluggish action, due to the necessity for diffusion. The increased resistance is admitted, but is stated to be unimportant. It must, however, be remembered that, small as the resistance of an accumulator is compared with the older forms of primary batteries, it already presents very considerable drawbacks, and places the use of storage batteries at a great disadvantage where heavy discharges are demanded. A jelly would be more desirable than an acid solution under the seats or floor of a tramcar, but already a limit has been reached in this application of electricity, which is due chiefly to internal resistance. If an attempt be made to discharge an accumulator in less than four hours, there is a serious drop in volts; and, even if the plates are not damaged, there are heating and several other evils. One of the best batteries for standing a heavy discharge has a very wide space between the plates, which of course decreases the conductivity. Dr. Paul Schoop says that when his gelatinous acid is used, the distance between the plates may be reduced, thus bringing the resistance down to an ordinary amount. If he can go farther and *actually* reduce it, he will do well. Tramcars do not need a four or five hours' supply. In many instances it would be far better if a supply for only two hours could be carried, provided that the weight of the batteries might thus be halved. The electrical omnibus would have a fair chance if a battery could be found which would do the bulk of its work in an hour and a half. A low resistance is not all that is wanted; but with a low resistance and a gelatinized solution, great strides might be made in electric traction by accumulators.

From Mr. Carter's reply to our comments on the magnetic circuit last week it appears that he has quite misunderstood their purport. We had no intention of implying that his analogy was in any way incorrect. We, however, wished to point out that, by comparing magnetic flux with electric charge instead of with electric current, the analogy can be pushed much further than it is otherwise possible to do. Mr. Carter's analogy is, indeed, a good one; but it cannot be much extended without breaking down. No doubt, magnetic induction, like the electric current, is of the nature of a flux; and each has a rate of fall of potential; but this is also true of electric charge, and, this being the case, we may compare the former with either of the latter. Clearly, the better one to choose is that which will yield the most complete analogy; and a little consideration will show that the electrostatic analogue is in this sense the right one to take.

With the electric circuit the product of the current by the fall of potential gives the rate at which energy is being expended, either in heating the circuit or for other purposes, while with the magnetic circuit the product of the number of lines by the fall of potential is a measure of the magnetic energy *stored*. This energy shows itself in the extra currents induced, when from any cause the magnetism is altered, and is quite analogous to the store of energy possessed by a condenser, and measured in precisely the same manner by the product of the charge and the potential of the coatings. The main objection which Lord Rayleigh, Dr. Hopkinson, and others have urged against the adoption of the term "magnetic resistance" arises from the association of the word "resistance" with "continuous expenditure of energy," and that, in conse-

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quence, such an extension of its use would be misleading. For similar considerations, Mr. HEAVISIDE proposed that the word "reluctance" should be substituted for "resistance," since the quantity denoted is analogous with the constant of a condenser, and not with the resistance of a wire. An electromotive force may charge a condenser by displacing a quantity of electricity proportional to its capacity, or generate a current in a wire by producing a continuous displacement of electricity, at a rate inversely proportional to the resistance. In the same way, a magneto-motive force may produce a number of lines of induction proportional to the electro-magnetic capacity of the circuit; and if a true magnetic conductor were known it would generate a magnetic current by producing a continuous displacement of lines.

THERE is one point in Mr. CARTER'S letter to which we must take exception. If the electrostatic analogy fails at some points, it certainly does not do so in the instance put forward. Mr. CARTER says, "The number of lines of *force* radiated from unit magnetic pole is independent of the medium, *i.e.*, the *stress* is independent." If by the word *force* Mr. CARTER means *induction*, the former part of the statement is right; but whether this is meant or not the latter part is incorrect. Mr. CARTER has, in fact, from disapproving the analogy between electric and magnetic charges, confused lines of induction with force in one case, and very clearly pointed out the distinction in the other.

THERE are some good points about the Smythe and Payne cut-out, which is described in another column, as it would appear that the size of the attachment cord is not of any great importance. The device seems to be open to the objection that its action would not be always instantaneous. If the cord be rather too thick, it will take an appreciable time to burn through; and the mechanical movement of the parts will also occupy a measurable interval. This objection was raised by a contemporary, some years ago, to a magnetic cut-out where a magnet released a tumbling weight or hammer by which a switch was knocked over; the objection, we think, is not unimportant. Have any experiments ever been made to ascertain if a sudden heavy current has time to do any damage before an ordinary cut-out has time to melt?

ONE or two fires have occurred in this country which must be attributed to the electric light. It is possible that in more than one case the real cause may be known either to the contractor who wired the house, or to an inspector who has subsequently examined it. In the absence of inquests as to the causes of fires, the true circumstances will rarely be made public. It is surmised that wood-casing set in damp plaster and never becoming properly dry; or casing which has subsequently become damp, may have set up some electrolytic action, resulting in a leak, then in charring, and eventually in a fire. The insulated cable used in the highest quality of wiring would oe safe for years in water. Can damp wood or damp plaster damage sound cable? Probably not. But if there be a leak, sufficient to allow, say, one hundredth of an ampere to pass from wire to wire, or from wire to earth, will damp wood and damp plaster tend to increase this leak? Many engineers say yes. Then, what will take place? The leak may be between two mains carrying 20 amperes, with a 24 ampere fuse. Can 24 amperes get across a reasonable distance through damp wood—if so, with what effect? Would a smaller current, which would not melt the fuse, do any damage? Is it a matter of time? Can a trifling leak develope into a dangerous short-circuit, under the conditions to which we have referred, in an hour, a week, a year? Does the current finally increase at a rapid rate? Can any one answer these questions from actual observation? If not, we hope that some experiments will be made. Nothing could be more easy, say, at a central station or laboratory than to put up a length of jerry work, including a bad joint or two; keep it damp, keep the current on, and keep a careful watch upon it; and, finally, send a report to our columns.

IN our issue of the 6th June we published a brief description, abstracted from a Belgian technical magazine, of the electrical arrangements on board the "Peral" submarine torpedo boat. Lieutenant Peral, as we announced a few days ago, has for his invention been awarded the sum of £20,000 by a grateful country; but we have it on the authority of the Paris *Figaro* that "the satisfaction of M. Peral has been troubled by an incident which is not without gravity. An English review, *The Electrician*, has published a complete description of the depth-regulating apparatus of the 'Peral;' and the question is, who can have betrayed this secret to the English. The matter is somewhat delicate, and it is to be hoped that an inquiry will be instituted. At Cadiz this publication has produced a profound impression, and M. Peral does not dissemble his vexation."

WE learn by telegram, just as we are going to press, that the Town Council of Brighton have accepted the tenders which we give in another column.

Drogheda.—The Irish House-to-House Electricity Company have announced their intention of applying for a Provisional Order.

Blyth.—The Local Board has received notice that it is the intention of a company to seek powers to supply electricity within its district.

Chesterfield.—The Corporation has received notice from Messrs. Cowdell and Davies of the intention of a syndicate to apply for powers to supply Chesterfield with electricity.

Acton.—A communication has been received by the Local Board from the House-to-House Electric Lighting Company to the effect that they intend to apply for a Provisional Order.

The Meudon Balloon Experiments.—According to *La Lumière Electrique*, the Meudon dirigible balloon is worked with a 70 horse-power electric motor, weighing only 490 kilogrammes.

Colchester.—At the last meeting of the Town Council a letter was read from Messrs. Latimer, Clark, Muirhead, and Co., stating that they intend to apply for a Provisional Order.

Electric Traction in Rome.—The tram line erected by the Series and General Electric Traction Company in Rome on the Series system was opened by the King of Italy on Sund y last.

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Worthing.—At the last meeting of the Local Board a letter was read from the Laing, Wharton, and Down Construction Syndicate, announcing their intention of applying for a Provisional Order.

Tunbridge Wells.—At the last meeting of the Town Council it was stated that the Electric Light Committee had agreed to ask the Council to make application for powers to light Tunbridge Wells by electricity.

Alnwick.—A communication has been received by the Local Board from the Northern Counties Electric Lighting and Power Supply Company, informing the Board that it is the Company's intention to apply for a Provisional Order.

Hamburg.—The Bremer electric tram, constructed by the International Thomson-Houston Company, at Hamburg, was opened on July 1st, and carried on the first day, with the three cars at present in service, 2,500 passengers.

Telephonic Extensions.—A telephone trunk line was opened last week, connecting Weston-super-Mare and Bristol.—The trunk wire between Dundee and Aberdeen *vid* Falkirk, Brechin, and Montrose, a distance of 200 miles, has been completed.

Southport.—The Corporation have received two notices of intended applications for Provisional Orders to supply electricity within the borough; and the Gas Committee have decided to recommend the Town Council to refuse their consent, and to apply themselves for an Order.

Electrical Bills in Parliament.—The Drypool Gas (Electric Lighting) Bill was read a third time in the House of Commons on Thursday evening. The Royal Assent was given on Friday last to the Electric Lighting Acts Amendment Bill (Scotland), and to the North Metropolitan Tramways Bill.

Electrical Units.—We are asked by Mr. R. T. Glazebrook to announce that it is expected that a discussion will take place at the forthcoming meeting of the British Association in connection with the Electrical Standards Committee on the best values to adopt for the units of electrical measurement.

Halifax.—At the last meeting of the Town Council, the Town Clerk read a letter from the National Electric Supply Company, giving notice of their intention to apply for a Provisional Order. The Town Clerk said a similar notice had been received from the Yorkshire House-to-House Electricity Company.

Loughborough.—At the last meeting of the Town Council notice was received from the Loughborough Electricity Supply Company of their intention to apply for a Provisional Order. This was accompanied with a letter stating that the application was made on behalf of the Brush Electrical Engineering Company.

Electrical Trades Section River Excursion.—The inclement weather on Saturday reduced the number of the party from 50 to 21. Owing to a hitch in getting ready the electric launch, the trip was made by steam. When the accounts are made up the balance will be returned to those who took tickets but did not go.

Troyes.—A workman connected with the recently-inaugurated transformer station at Troyes, who had been engaged in connecting a transformer to the mains, stumbled on leaving the cellar in which he had been at work, and fell. In his fall he caught hold of the transformer and pulled it completely down, and received a fatal shock.

London Chamber of Commerce.—The following gentlemen were amongst those elected members of the London Chamber of Commerce at the last Council meeting:—J. A. Brown, electrical engineer; W. Johnson, secretary and engineer of the Sheffield Telephone Exchange and Electric Light Company; Arthur Shippey, electrical engineer.

City and Guilds of London Institute.—The post of Senior Demonstrator and Lecturer in the Department of Electrical Engineering at the Technical College, Finsbury, has become vacant by the appointment of Mr. Robinson to the Professorship of Mechanical Engineering at Nottingham. Further particulars will be found in our advertisement columns.

The Post Office Jubilee Conversazione.—We are glad to hear that the net result of this *Conversazione* has been an addition of £10,000 to the Rowland Hill Benevolent Fund. It is to be hoped that this result, of which the Post Office may well be proud, will still further mitigate whatever mild indignation may have been caused by the "electro-phonoscope" hoax.

The Telegraph in South Africa.—The first office in the British South Africa Company's telegraph system has been opened at Ramoutsa, in the British Protectorate, 77 miles north of Mafeking. The second, at Mascheedi, about 50 miles further north, will be ready next week. Cablegrams for these offices will cost 3d. per word in excess of the present tariff.

Exeter.—The Town Council having been applied to by the Devon and Cornwall Electric Light Supply Company for sanction to apply for a Provisional Order to light the city with electricity, it was resolved at the meeting on Wednesday to appoint a committee to consider whether the Corporation should not itself apply for a Provisional Order for the same purpose.

Electric Launches.—We are informed by Woodhouse and Rawson, United, that they have purchased the business of electric and steam launch builders formerly carried on by Messrs. W. Sargeant and Co. at Strand Works, Chiswick, W. Mr. Sargeant has been retained as branch manager; and they intend to pay special attention to the building of electric launches and charging stations.

Copper.—Even with the advance in prices, the demand for copper, says *The Statist*, appears to be expanding, and for June the deliveries are reported as amounting to the very large total of 18,781 tons, the largest monthly delivery on record. The supplies of the month have been a little (400 tons) larger than in the previous month, and the stock has been reduced by nearly 10,000 tons, amounting on June 30th to 72,493 tons, against 111,689 tons this time last year.

Submarine Cable Manufacture in France.—The submarine cable between Demerara and Cayenne, a distance of 230 miles, has just been laid. This is the first submarine cable constructed by the Société Générale des Téléphones since it took up this branch of cable manufacture. The same firm have in hand 3,000 miles of cable for the Société Française des Antilles. The Société Générale is erecting large submarine cable works at Calais, and has given an order for the construction of a cable ship.

Bath.—At the last meeting of the Town Council some letters by the Bath Sanitary Committee were read, calling attention to defects in the electric lighting which had disclosed themselves since the wet weather set in. Mr. Massingham, it seems, has expressed his regret for the imperfections, and pointed out that they arose from the fact that the wet weather had found out weak connections between the mains and the lamps, which owing to the work being hurried towards the last had not been found out by experimental runs.

University College of South Wales.—Dr. Elliott, of the University of Edinburgh, out of a total of 39 candidates, has been appointed Professor of Engineering at the University College of South Wales and Monmouthshire. He will enter upon the work of the organisation of his department, planning out the necessary buildings, &c., at once. Dr. Turpin, who is a graduate of the University of London, and a first-class man in the Natural Science Tripos at Cambridge, has been appointed Lecturer and Demonstrator in Chemistry at the same College.

Amsterdam.—The Town Council has passed the Bill fixing the rules and conditions under which the electric lighting of Amsterdam shall be entrusted to those tendering in open competition for the contracts prior to September. The contractors will have to pay the Corporation 5 per cent. per annum on all receipts; of the balance, 6 per cent. will go to the contractors, who will also receive one moiety of the surplus, the other moiety going to the consumers. The Town Council is to have the right to readjust the charges for electric lighting every five years, and may lower them if found unreasonable or excessive.

Wire Table.—An "International Wire Table," compiled by Mr. Wilfred S. Boult, will shortly be published, containing full particulars of 451 electrical conductors, ranging from 2·26in. to ·001in. in diameter, and including single wires and cables of

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the Standard, the Birmingham, the Brown and Sharpe, and the metric gauges, arranged in consecutive order according to cross-section, so that when any conductor is looked up it is at once seen what are the nearest sizes in the other gauges. Full particulars will be given with regard to each of the 451 conductors as to cross-section, gauge, weight, and resistance, in English, American, and Continental units.

Electricity and the Law.—In a recent number of the *Political World* it is pointed out that nobody knows under the Electric Lighting Acts whether central-station plant, on being purchased by a Local Authority, is to be valued as an integral part of a working and successful concern—if the concern be successful—or simply as so much isolated machinery and material distributed in different places. "That," remarks the *Political World*, "is the pleasant little problem which our disinterested lawyers—always ready to help the nation in its difficulties—are looking forward to solve in the future. In the meantime, might not our legislators bring in a few interpreting Acts?"

Leeds.—The following additional particulars with regard to the electric light installation at the offices of the *Yorkshire Post*, to which we referred in our last issue, may be of interest. The order for the installation was only given to Mr. Wilson Hartnell at 11 o'clock in the morning, and it was at work at a few minutes to 11 the same night. Operations were commenced at 2 p.m. The power for driving the dynamo was already on the premises, but excavations had to be made to make room for the driving pulley on the main shaft. Pulleys had to be bored and turned, a special countershaft had to be provided with the necessary pulleys, foundations for dynamos, &c. At five minutes to 11 the work was so far completed that the whole of the composing-rooms, where over 100 hands are employed, the printing machine room, and, in fact, the whole place where night work is required, was brilliantly illuminated.

The Manufacture of Celluloid.—The manner in which celluloid is made in France is as follows:—A huge roll of paper is unwound slowly, and while unwinding is saturated with a mixture of five parts of sulphuric and two parts of nitric acid, which is carefully sprayed upon the paper. The effect of this bath is to change the cellulose in the paper into pyroxyline. The next process is the expelling of the excess of acid in the paper by pressure and its washing with plenty of water. It is then reduced to a pulp and bleached, after which it is strained, and then mixed with from 20 to 40 per cent. of its weight in water. Then follows another mixing and grinding, after which the pulp is spread in thin sheets, which are put under enormous hydraulic pressure and squeezed until it is as dry as tinder. These sheets are then put between heated rollers and come out in quite elastic strips, which are worked up into the various forms in which celluloid is made.

Thunderstorms.—Further accounts show that the thunderstorms which occurred at the end of last week did considerable damage both to life and property. At Chapel St. Leonard's, near Sutton-on-Sea, a waggoner was working with a reaping machine when he and his horse were struck by lightning and killed. At Hanslope (North Bucks), some barns were struck by lightning and caught fire. The buildings were entirely consumed. At Ilmington, an oak tree was struck and the lightning took the top of the tree completely off, leaving the body of the tree, which was about 10ft. high, split down to the ground, the bark being projected a distance of thirty yards. In the Cleveland district, the Eston Steelworks were struck by lightning, and a portion of the roof collapsed, bringing to the ground five principals and a girder, several tons in weight. At the time of the occurrence a large number of men were engaged in this portion of the works, and four were injured by the falling material.

Gas Pipes damaged by Lightning.—On the 28th ult., during a severe storm, Filey Church was struck by lightning. The church tower is surmounted by a weather-cock attached to an iron rod fixed on an oak mast. The lightning struck this mast just where it was joined to the rod bearing the vane, and, splintering it into matchwood, tore up the lead covering of the roof, and running down the side of the building smashed a pipe connected with the heating apparatus. It seems then to have entered the church, but without doing any damage until it reached the ground, where it snapped upwards of 12 gas-pipes connected with the main outside. Running underground along this main, the electricity broke the main-pipe in several places at the junctions, until it reached a point opposite a farm-house, where it extinguished the gas in a cooking-range, and went apparently to earth. The gas-main is a 1½in. cast-iron pipe with turned and bored joints. The damage extended over some 80 yards; and, in that length, eight or nine of the sockets were split open, in some instances pieces of the sockets being broken completely off. The fractures were all on the underneath side of the pipes. The soil is a clayey loam, and was fairly dry. The church had no lightning conductor to it.

The Series Storage Battery.—Messrs. Mark Bailey and Co., of Cadby Works, Leather-lane, have submitted to us a specimen of their new storage batteries. These are intended, at present, for use on a small scale, for carriage lighting, &c. The battery consists of a wooden cell, divided into separate partitions by the battery plates. The opposite sides of a plate are therefore of an opposite character; one side being as it were, positive, and the other negative. The plates in a cell are therefore in series, and no electrical connections whatever are required, except at the two end plates. A wooden frame between the plates prevents buckling. A box 14in. long, 4½in. wide, and 6in. deep, will contain a battery of 24 plates, that is 24 cells; and this, we are informed, will yield 18 amperes at 48 volts. The plates are cast with square recesses, for holding the peroxide, and probably would discharge at a rate comparing fairly with other accumulators. For lightness and small space the arrangement appears very good; but in the absence of any prolonged test for durability, it is impossible to say whether the tendency to buckle has been overcome. Some six years ago we tried the series arrangement of conical cells, which has been re-invented scores of times; buckling does not describe the contortions into which the soft lead plates threw themselves.

Eastern Telegraph Company.—The Report of the Directors of this Company for the half-year ended March 31st last will be found in our present issue. The Directors announce the conclusion of arrangements with the French Government for the renewal of the agreement for the Company's direct line through France, and for the landing and working of submarine cables at Marseilles; and also the renewal of the agreement between the Postmaster-General and the Company for a special wire by land line and cable connecting the French line with London. The Italian Government have prolonged for twenty years the existing concession to the Company for the working and maintenance of their cables between Italy, Malta, Corfu and Egypt. The Company have also concluded an agreement with the Turkish Government for a short cable between the island of Perim and Sheikh Seyd, by which the Company's system will collect traffic from various points on the Arabian coast. The Directors state that the Company's interests were carefully watched at the recent International Telegraph Conference at Paris by the Chairman, the Managing Director, and other representatives of the Company, and that the result has been on the whole not unsatisfactory. The Report concludes with the announcement that the new Red Sea cable, to take the place of the original cable connecting Suakim with Suez and the Island of Perim, will most probably be in working order before the end of the year.

Investigation of the Stanley Alternate-Current Arc Dynamo.—The graduating thesis of Messrs. Tobey and Walbridge, of Cornell University, embodies an experimental investigation of the new Stanley alternate-current arc machine. The general method was to obtain instantaneous values of electromotive force and current at a sufficient number of points to indicate by curves the performance of the machine at every part of a revolution. For this purpose a condenser was charged by a suitable commutating device to the potential it was desired to measure, and then discharged through a ballistic galvanometer. Readings of arc and field current were taken by fall of potential method. The E.M.F. curve exhibited a very peculiar form, approximating more nearly to a rectangle than to a sine curve. The reversal of

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direction was very abrupt, the E.M.F. at a load of 20 lamps changing during 3·8deg. from 960 volts positive to 1,560 negative, making a total of 2,520 volts. This effect is due to the action of the arc, for when the machine worked on non-inductive resistance (incandescent lamps), the curve of E.M.F. approximated quite closely to a sine curve. The arc current in all cases approximated to a sine curve, and the field-current exhibited a wiry form, the maxima of this and the arc current curves corresponding. The current lag in all cases was very small, increasing slightly as the load increased. The zeros of both E.M.F. and current moved backward slowly with reference to the pole-pieces as the load became greater. For all runs yet taken for over half load, the machine showed an efficiency of over 90 per cent.

Cape Telegraphs.—The following notes are extracted from the report of the Postmaster-General of the Cape of Good Hope:—The postal and telegraph business having grown amazingly since 1872, when the present offices were taken, a building specially designed for the service has become necessary, and during the last Session the sum of £10,000 was voted to acquire a site. During the year 2,824,153 messages, containing 58,499,902 words, were received and forwarded. There were 4,510 miles of telegraph, carrying 11,325 miles of wire, and necessitating the use of 411 sets of apparatus. The telegraph receipts for the year were £94,929, as compared with £70,243 in the previous twelve months, the value of Government messages being £47,490. The total revenue, reckoning Government telegrams, was, therefore, £142,419, and the expenditure on working and maintenance £67,232, leaving a profit on working of £75,187, equal to more than 19 per cent. on the total capital expended on telegraph lines to December 31st, 1889, which was £387,448. The question of free transmission of newspapers throughout the Colony has been mooted, but the Postmaster-General has not felt himself at liberty to favour the proposal. The experiment has been tried by only two or three out of all the postal administrations in the world, amongst which are Natal and New South Wales. The Postmaster-General of both these colonies report against the free carriage of newspapers, on the ground that the postal service was carried on at a loss. The estimated loss to the Cape Colony owing to the exemption of newspapers from postal charges would be about £12,000 per annum.

The Birkenhead Electric Lighting Bill.—This Bill came before a Select Committee of the House of Commons, presided over by Mr. Stansfeld, on Thursday last week. The National Telephone Company were the only opponents. The point on which there was opposition was contained in the sixth clause, which provided that the undertakers should so construct their works that they should not injuriously affect the working of any existing telephonic or telegraphic circuits. The opponents desired that the word "existing" should be left out of the clause, so that it should apply to works that might hereafter be constructed. Dr. Fleming and Mr. Shoolbred, C.E., gave evidence on behalf of the promoters, and Sir William Thomson and Dr. John Hopkinson gave evidence on behalf of the petitioners. It was announced that this being a test case, whatever the Committee decided would be adopted by the Board of Trade, and amendments made accordingly in all the Orders now before Parliament. The clause as amended runs as follows:—"The undertakers shall construct their mains and other works of all descriptions, and shall work their undertakings in all respects, so as not injuriously to affect the working of any existing electric circuits from time to time used, or intended to be used, for the purpose of telegraphic, telephonic, or electric signalling communication, or the currents in such circuits, and shall use every reasonable means in the construction of their mains and other works of all descriptions in the working of their undertaking to prevent injurious affection, whether by induction or otherwise, to any electric circuits used or intended to be used for the purpose aforesaid, whether existing at the time of the construction of such mains or other works or not."

The Modling-Hinterland Electric Railway.—In a recent number of the *Révue Générale des Chemins de Fer*, M. Maurice Bellom gives some particulars with regard to this line, the first section of which was in operation as far back as 1883, and the last section of which was completed in 1885. The line is of 1 metre gauge and 4·4 kilometres (2¾ miles) long. The steepest gradients are 1½ per cent., and there are some curves of 100 feet radius. The plant comprises one 140 and three 15 horse-power engines, and six compound-wound Siemens machines, having an output of 30 amperes at 500 volts. The motors, which are series-wound Siemens machines, are arranged under the car, spur gearing being used, and the speed being reduced in the ratio of 6 to 1, the cars running as a rule at the rate of 9½ miles per hour. The circuit is entirely metallic, and runs overhead on wooden posts 18ft. high and 90ft. apart. The conductor consists of a split iron tube, in which there slides a brass contact piece attached by wires to the roof of the car. To take the strain off the conducting wires, the slot is pulled along by means of a rope. The overhead arrangements are, in fact, similar to those employed in the Frankfort-Offenbach line, described in *The Electrician* of March 23, 1888. The contact piece lasts for about two months without renewal. During the winter only one train is employed, but during the busy season three trains, and on Sundays and fête days six trains are running simultaneously. Each train consists of a thirty-passenger motor car, weighing 4·1 tons, and a thirty passenger car without a motor, weighing 2·8 tons. These weights, together with a full complement of passengers, make a total load of 11·1 tons. The maximum resistance to traction is found to be about 24lb. per ton. With six trains running, 8,000 passengers can be carried in a working day of 14 hours. Tests have shown that with a single train at work, the difference of potential at the dynamo terminals is 500 volts, and at the distant terminals of the line 390 volts, the current strength being 30 amperes. The first cost of the line was somewhat high, amounting to a grand total of 1,317,714fr. (£52,708). The working expenses in 1887 were 36,645fr. (£1,457), leaving a net profit of 67,539fr. (£2,701). In 1888 the net profits were 71,089fr. (£2,850), or 5·4 per cent. upon the first outlay.

A Time Circuit Cut-Out.—One of the troubles incurred in commercial lighting, says the *Electrical World*, is that part of the customers require lights, say up to 7 o'clock p.m., another portion till 9 or 10 o'clock, and still others until midnight; and these various patrons are not considerate enough to arrange themselves so that a separate circuit can be conveniently supplied to each class. An appliance has been brought out by a Mr. Elkins, of Boston, to give the central station absolute control over all the lamps supplied by it, and to enable all lamps belonging to one class of service to be shut off at the proper hour. The apparatus consists of a step-by-step ratchet movement, actuated by a small electro magnet and controlling spring switch, which short-circuits the loop containing the lamps which it is intended to cut out. A small pin inserted at various points in a dial above the ratchet wheel adjusts the apparatus to spring the switch by any desired number of movements of the magnet. The working of the circuit is as follows:—A special circuit is used, and in it all the cut-outs are inserted in series to each other. At the station this circuit is cut into the main line across the terminals of a resistance through which the current can be shunted. The difference of potential between the ends of this resistance is sufficient to throw the desired current around the signal circuit. Let it be supposed that it is desired to run on the same line 7 o'clock lights, 9 o'clock lights, and midnight lights. At the entrance to each customer's place of business is placed the cut-out in a closed box. The ratchets of all cut-outs to control 7 o'clock lamps would be adjusted to spring the switch by three impulses of the magnet; all the 9 o'clock lamps would be adjusted to require, say, five impulses, and the midnight lamps seven. At 7 o'clock the operator at the central station would open the switch in the loop containing the resistance, and would then press the key in the signal circuit three times, which would cut out all the 7 o'clock lights on the line. At 9 o'clock two additional strokes of the key would cut out the 9 o'clock contingent, and at midnight two more strokes would extinguish everything except the all-night lights. When the lamps are trimmed in the morning the trimmer inserts the key in the box and sets the cut-out ready to be operated at the desired hour.

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MAGNETISM IN IRON AND OTHER METALS.*—XXIII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 223.*)

§ 89. **Further Experiments on Time-Lag in Magnetisation.**—Similar differences between the immediate and ultimate action of magnetic force on soft iron present themselves when we examine the effects of small increments of the magnetic force at any stage in the process of magnetisation. In another experiment, which was made with the same specimen of annealed wrought iron, the magnetising force was applied in a series of small steps—each step being produced by a rapid but not quite sudden augmentation of the magnetising current. The immediate effect of each step was balanced by means of the compensating coil, and after each step a pause of one minute was made during which the gradual growth of magnetism was observed. The results are shown in the full lines of Fig. 60; the dotted line has been added to show that the points reached after the pauses of one minute lie in a continuous curve. As the experiment was continued into higher points of the magnetisation curve, the compensating coil had to be pushed a little nearer the magneto-meter to procure a perfect balance: in other words, the immediate effect of the step became somewhat greater. At the beginning, the instantaneous value of $\frac{dI}{dH}$ was about 10; but when the experiment of Fig. 60 was extended until the force produced by the magnetising solenoid was 3 C.-G.-S. or, so and I was about 320, the instantaneous value of $\frac{dI}{dH}$ rose to 13. At that region of the curve, the creeping-up of magnetism after a very small step-up of the current was enormous; in the course of one minute it amounted six or seven times the immediate effect of the step. Fig. 61 illustrates the kind of action which is observed when a small increment of magnetising force is made to take place quickly after a pause anywhere in the steep part of the magnetising process, the metal dealt with being soft wrought iron. The dotted line is the normal slope of the magnetisation curve when the process of magnetising is performed slowly. A very small increment of H rapidly performed after a pause at P produces an immediate effect, P Q, which is followed by the slow creeping up Q R. It is only when the step is a very small one that P Q correctly represents the immediate effect.

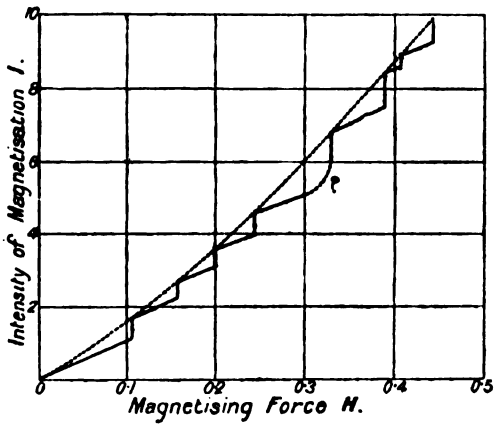

FIG. 60.—Effects of steps in the magnetisation of a soft iron rod.

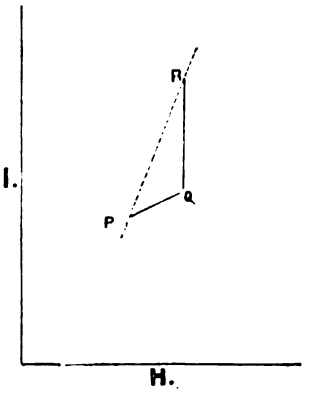

FIG. 61.

Very interesting results are obtained in examining how the time rate of creeping up after a step is affected by the length of the pause (under constant force) which preceded the step. When the preceding pause is long the creeping up which follows a step goes on much more slowly than when the preceding pause is short.* In an experiment with the same specimen of soft iron the effects of two equal small steps were compared, both made in the same region of the magnetisation curve, one after the magnetising force had been kept constant for three minutes, and the other after it had been kept constant for an hour. The immediate effects were the same; but the subsequent creeping up, which was observed during no less than ten minutes, went on so much faster in the former case that it amounted in ten minutes to 531 scale divisions of the magnetometer, as against 320 scale divisions in the latter.

The effects of an alternate small step up and step down, performed at any stage in the process of magnetisation, are quite like those that have been shown in Fig. 57. After the steps have been repeated often enough to bring about a cyclic set of changes, the instantaneous value of $\frac{dI}{dH}$ becomes approximately the same as at the initial part of the curve—namely, about 10 in the particular specimen examined—unless the whole magnetisation approaches saturation, in which case the value of $\frac{dI}{dH}$ is distinctly less. The diagram (Fig. 62) represents in a general way the change of magnetism which takes place when any very small periodic variation of magnetic condition is made to occur in a soft iron bar, about a mean condition O. If the changes of force occur fast and without pauses the cycle is shown by the lines $a\,a'$ and $a'\,a$. They enclose no area, and there is no dissipation of energy. If, on the other hand, the changes of force occur gradually and very slowly the cycle is shown by the lines $c\,c'$ and $c'\,c$. They also enclose no area; and again there is no dissipation of energy. But if the changes of force take place quickly, with pauses at the extreme values, the cycle is $b'\,c'\,b\,c$, and an amount of energy is dissipated which is to be measured by the area of that parallelogram. In most actual cases in which the force varies periodically it does so not suddenly with pauses at the extreme values, but in such a manner that a loop will be formed instead of the parallelogram. When the frequency of the alternations is very great, the loop will flatten itself into the straight line $a\,a'$; when the frequency is very small it will again flatten itself into the straight line $b\,b'$. With any frequency lying between these extremes there will be dissipation of energy, and when the limits and mode of variation of the force are specified, there must be some particular frequency which will make the amount of energy dissipated in the cycle a maximum.

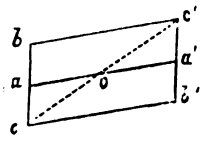

FIG. 62.

In hard iron and in steel the phenomenon of time-lag in magnetisation occurs, but so slightly as to be scarcely observable. A piece of the same wire as had been used in the above experiments was hardened, after being annealed, by stretching it a little beyond the limit of elasticity. Scarcely a trace of creeping could be detected when a feeble magnetic force was applied

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* *Loc. cit.*, p. 280.

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to the wire in this hardened state, but it was possible to produce a measurable amount of creeping by first applying a moderately strong magnetising force, and then making a small step up after a pause. The initial instantaneous value of $\frac{d\,I}{d\,H}$ for a small step was 5·3.

The whole phenomenon depends much on the size of the specimen that is tested. In the experiments which have been described the iron was a rod four millimetres in diameter. Smaller rods showed much less magnetic viscosity, and when a bundle of fine annealed iron wire was substituted for the rod, nearly all trace of "creeping" disappeared. The cause of this difference is at present obscure.

§ 90. **Molecular Accommodation.**—Closely related to the experiments which have been detailed in this chapter are results recently published by H. Tomlinson.* Examining the action of feeble magnetic forces, in the region within which the relation of **B** to **H** may be expressed (§ 86) in the form

$$\mathbf{B} = a\,\mathbf{H} + b\,\mathbf{H}^2,$$

he has discussed the influence of temperature and other conditions on the constants a and b. The constant a is of course the initial permeability, and it is on the value of b that the dissipation of energy depends. Some of the more interesting of Tomlinson's results may be briefly stated in his own words:—

"The internal friction of iron, nickel, and cobalt in any complete cycle may be decreased by repetition of the cycle; the molecules are said to be 'accommodated' by this process.

"The molecular 'accommodation' of freshly annealed iron can be largely aided by repeatedly raising the metal to 100°C, and then allowing it to cool.

"The 'accommodation' of the molecules of iron, nickel, and cobalt is disturbed by very slight mechanical shocks, by small change of temperature, or by magnetisation beyond certain limits; under such influences the internal friction may for a time, or even permanently, be considerably increased.

"The values of a and b for iron are temporarily increased when the temperature is raised from 0°C. to 100°C."

(To be continued.)

THE EDINBURGH EXHIBITION.—II.

Messrs. Smythe and Payne's Exhibit.

Amongst the exhibits of Messrs. Smythe and Payne, of Glasgow, at the Edinburgh Exhibition is an ingenious non-fusible safety cut-out. This cut-out makes use of the heating effect of a current without employing the high temperature necessary to fuse a wire. The principle of the device is as follows:—A conductor is employed, having a smaller sectional area than that of the wire forming the circuit which is to be protected; around this conductor is passed a cord made of a material which is easily charred or rendered brittle by the action of heat, and this cord holds in check a mechanical contrivance for breaking the circuit, which is controlled by a spring or a weight. When the conductor becomes overheated by an excess of current this cord gives way, releases the spring or weight, and allows the mechanical contrivance to come into action and break the circuit. This cut-out can be made in a variety of different forms, to suit the requirements both of high and low potential working. The figures shown will serve to illustrate the principles and construction of two out of a number which have been made. This device is also applied to switches themselves in such a manner as to render a separate cut-out unnecessary.

In Fig. 1 the contact bar B is centred at one end, a handle to work it being fixed at the other. If the cord A breaks, the hammer H, assisted by a spring S, knocks out the switch, which cannot be turned on again until the hammer has been drawn up and the cord replaced. A hammer, actuated by a spring, can be fitted to many different forms of switches, such as the circular pattern usually adopted for all the small single lamp switches. A good method of constructing a combination switch and cut-out is to employ some form of catch or trigger to hold the switch on; the catch is released by the hand under ordinary circumstances for switching off, but the operation is performed automatically by a spring or weight released by the attachment when there is an excess of current.

The form shown at Fig. 2 is designed to give a long break, and to ensure certainty of action, even though the contacts have become clogged with dirt and dust. Contact pieces, P_1 P_2, are fastened to the bar B, made of insulating material, and connected together by the conductor C. At both ends of the bar springs, S S, are fastened, which press against the contact-holders, H_1 H_2. The springy contact-pieces P_1 P_2 are

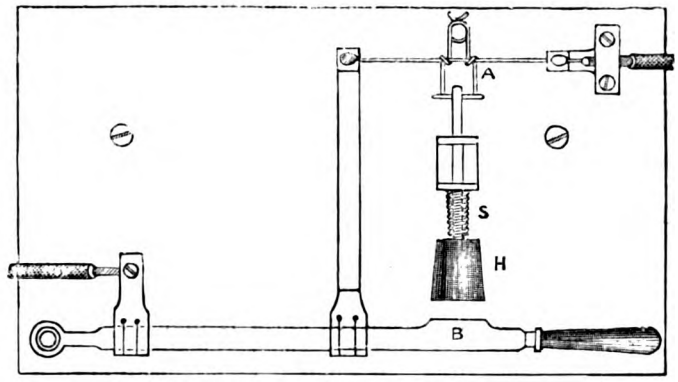

Fig. 1.—Smythe and Payne Safety Cut-Out.

pushed up into the holders, and held fast by the outward pressure of the toggles G G, made of insulating material. This pressure is due to the pull of the attachment cord A, which is secured to the toggles and also to the bar B, pressed downwards by the springs S S. When the cord which is passed round the conductor C gives way, the pressure on the contact-pieces, P_1 P_2, is removed, and the bar is free to fly out, thus leaving a break between the holders H_1 and H_2. The bar B can be replaced when the cord is renewed, without danger to the operator.

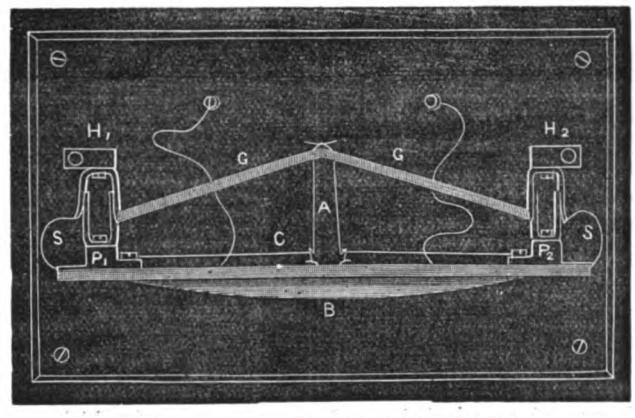

Fig. 2.—Smythe and Payne Safety Cut-Out.

The advantages of this form of cut-out are that there is no fusion of wires; the conductor can be soldered down and used over and over again. A new attachment cord is more easily procurable than a special fuse wire of the exact size and material required, which recommends the cut-out for ship-lighting. Some of these cut-outs are manufactured by Messrs. Fowler, Lancaster and Co., of Birmingham. Messrs. Smythe and Payne have carried on numerous experiments with a view to ascertain the best material for the attachment cord, and have tried jute, cotton, flax, hemp, silk, horsehair, leather, gut, and other cords. They find on the whole that gut answers the best, since it does not catch fire even if the conductor reaches redness before the cord breaks; it stands the continuous strain of the springs or weights, it gives way quickly and at a lower temperature than other materials, and is the least affected by

* *Proc.* Roy. Soc., December 5 1889.

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moisture. In all the experiments made they state that they never saw a cord catch fire, although they tried coarse strings wrapped round fine wires, which had time to get red-hot before the cord was cut through. Fishing lines, which are made to resist the action of salt-water, make very good attachments, as they are strong and durable. By passing the cord spirally round the wire, as in Fig. 1, the sharp curves are avoided which might tend to snap the gut, especially where fine wires and strong springs are employed. The strain of the springs or weights is not directly on the wire, but on a peg or hook to which the cords are attached.

Exhibit of MM. Van de Plancke.

MM. Van de Plancke, of St. Nicholas (Waes), Belgium, have a large show of electric clocks. A reference to the annexed diagram will explain the arrangements adopted in this system. The diagram shows the movement for the regulator. An unequally weighted fly-wheel, A, fixed on the arbor C, keeps by the unequal distribution of the weight the same relative position with regard to the pins D E H when the wheel is at rest. Consequently, a sudden forward motion of the lever R, produced by the attraction of the armature K towards the electro-magnet L, causes the lever to strike violently against the pin E, and to turn the fly-wheel in the direction of the arrow. The second pin H passes underneath the lever R, and after the revolution of the wheel prevents the continuation of the movement coming again in contact with the lever, which is brought back to its first position by the spring S. The turning of the fly-wheel has the following effect. It winds at each interval of time, for instance, every half minute, by means of a pinion fixed on the arbor of the wheel, the spiral spring on the barrel as much as it has been relaxed on producing the motion of the clock during

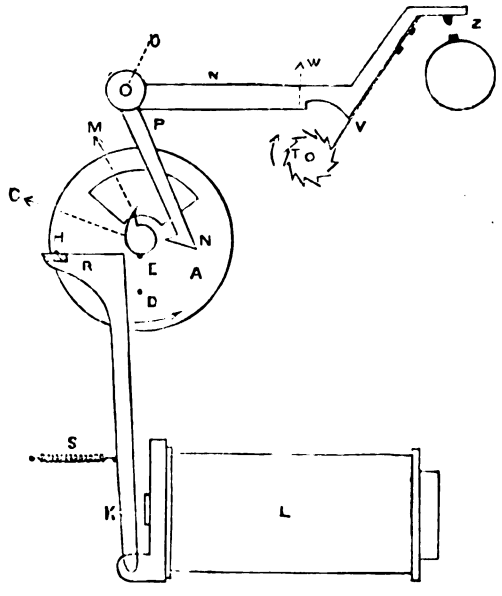

Fig. 3.

the same interval of time. It turns the cam M, which meeting the pawl N of the lever P lifts the latter and the lever N, both fixed on the axle O. This movement breaks the contact at Z, and allows the spring V to engage in the next tooth of the ratchet T. It also keeps the circuit broken. The ratchet wheel T, fixed on the middle wheel of the clockwork, moves in the direction of the arrow. The spring V, fixed on the lever N, pushes the ratchet wheel, and helps the movement until the notch W meets the next tooth. At this moment contact is made at Z. The electro-magnet attracts the armature, and the cycle of operations is recommenced. The movement of the receiving dials are constructed in much the same manner as the movement of the regulator. Every contact at the regulator sends the current into the coils of the receiving dials, and makes the hands move forward half a minute. One of the principal advantages of the system is the short contact, which is only $\frac{1}{8}$ of a second. Leclanché cells, wet or dry, can thus be used without fear of polarisation. There is but one contact in the circuit of regulator and receivers; and small and large receiving dials can work in the same circuit. A special form of regulator is constructed for the navy. In this form the required daily advance or retardation can be effected automatically in all the receiving dials throughout the ship.

A METHOD OF LOCALISING PARTIAL OR DEAD-EARTH FAULTS IN INSULATED CONDUCTORS.

BY H. CUTHBERT HALL.

This method is applicable to the elimination of faults from leads which have not been laid in pipes, or otherwise rendered inaccessible for manipulation.

The mode of procedure is as follows:—The cable in which the fault occurs is wound on an iron drum of special construction, as shown in the diagram below (No. 1). A is the barrel

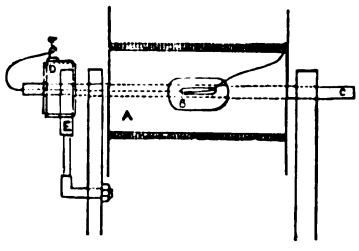

Fig. 1

of the drum, B an aperture cut in the barrel large enough to admit a man's hand, C a hollow tube which acts as the spindle of the drum. In C a slot about 10in. in length is cut, and to one end of C an insulated collector, D, is fixed. A brush E, also insulated, and fixed to the stand which supports the drum, makes contact with the collector D. One end of the cable to be tested is passed through the aperture B, threaded through the slot in C, and attached to a terminal on D. The other end of the cable is led through a vessel containing water and insulated from the ground, the cable being then wound on an iron drum, mounted on an iron stand. In diagram No. 2, Z represents the water vessel,

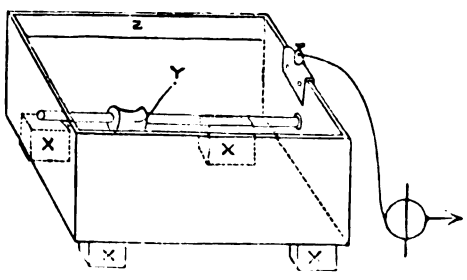

Fig. 2.

X, X, X, X, the insulating supports, and Y a pulley fixed under the water, and under which the cable passes. The end of the cable on A is connected to one pole of a battery by a lead, one end of which is attached to a terminal fixed to the brush, E. The other pole of this battery is put to earth. In the insulated water vessel, Z, a metal plate dips, to which is attached, by a terminal above the surface of the water, a lead connected to a Thomson galvanometer. The other side of the galvanometer is put to earth. While the fault or weak place remains on the drum, A, no deflection is obtained on the galvanometer; but as soon as the fault leaves the drum the galvanometer is deflected, this deflection being greatest at the moment when the fault enters the water. Thus a fault or weak place can be localised with great accuracy, even to a few inches.

The advantages claimed for this method are, that all cutting of the outside sheath of the cable is avoided; a great number of weak places in a cable can be localised in a very short time, the time occupied in detecting the faults being dependent only

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on the speed with which the cable is wound from one drum to the other; faults of very high resistance can be localised with accuracy, any variation in the insulation resistance of different parts of the lead being at once apparent on the galvanometer. The test is not applicable to armoured cable, but has been used by the author with complete success with tape-covered, felted, and braided lead or cable. In the case of braided lead, this method of localising faults is of exceptional value, as the expense of repairing faulty braided lead is very much augmented by the fact that any cuts in the braiding have to be repaired by hand.

A distance of several yards between the first drum and the tank is advantageous, as the absence of deflection on the galvanometer, while the fault remains upon the drum, is dependent upon the resistance of the sheath of the conductor between the drum and the tank. Also it is desirable, for this reason, to have the cable as dry as possible before beginning to

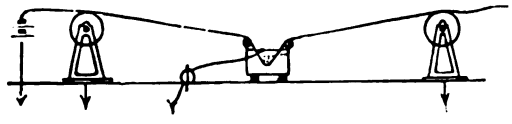

Fig. 3.

test. Neither of the above precautions is, however, essential to the test; but the best conditions for making the test are not obtained if these points are neglected.

In diagram No. 3 a general arrangement of the test is shown, which will make the above description more easily understood.

GELATINOUS ELECTROLYTES FOR STORAGE BATTERIES.

BY DR. PAUL SCHOOP.

An electrolyte for battery purposes is expected to be of high conductivity and to be constant during the use of the cell. Both conditions are fulfilled with a solution, particularly if it is kept in constant motion. As a rule the less fluid a solution is, the greater its resistance. But the fluid state of an electrolyte also presents disadvantages, at least from a practical point of view. The solution is easily spilled, it evaporates, its density becomes unequal. The dry cell has lately come into use for testing purposes on account of its transportability, though the capacity of it is inferior to the fluid cell.

For secondary batteries a solid electrolyte has even more importance than for primary batteries. As is well known, the storage of the current is effected by means of a spongy material, both on the positive and the negative plates; and it matters not whether this has been applied to the electrodes (or plates) mechanically or chemically. Practical experience shows that under ordinary circumstances the active material frequently drops out, and sometimes short-circuits the plates. If the cell is much shaken, as in the case of traction cells, the liability of detaching the active material becomes increased. Therefore, many efforts have been made to render the liquid solution more stiff; and sand, glass-wool, cellulose, asbestos-fibre, woollen-fibre, and saw-dust have been proposed. None of these substances have been used on an extensive scale, for the obvious reason that their absorbing power is not large; moreover, being non-conductors, these substances introduce a large resistance. But there are some bodies a very small quantity of which may convert fluids—water, for instance—into a solid mass. Glue, gelatine, agar-agar, starch dissolved in water (about 3 to 5 per cent. of the weight of the water) make it gelatinous. These substances have, of course, also been tried, but without success. Acids produce chemical reactions upon these bodies, and soon convert them into a fluid mass again; so also do some salts (chloride of zinc, for instance). No organic matter is likely to stand the action of the highly active oxygen developed by the electrolysis of water, even if it should stand the action of the sulphuric acid.

There is an inorganic substance, one of the most stable compounds known in chemistry, which has important gelatinising qualities, silicous acid. The salts of this acid, silicate of sodium and in a less degree silicate of potassium, are in common use. To obtain the gelatinous form of silicous acid, a dilute solution of silicum of sodium, say of 1·100 specific gravity, is mixed with dilute sulphuric acid of 1·200 specific gravity. Hydrochloric acid, or nitric acid, or nearly any other acid, will answer the purpose; also, all salts of ammonia, mixed with the solution of silicate of sodium, precipitate gelatinous silicous acid.

Suppose a storage cell has to be filled with gelatinous electrolyte. Three volumes of sulphuric acid, specific gravity 1·250, are mixed with one volume of silicate of sodium, specific gravity 1·180. The mixture remains at first perfectly fluid, but becomes more and more stiff and thick, and is gelatinous after two hours. After 24 hours the maximum stiffness is apparently reached. In charging the cell an interesting phenomenon is observed. As more current is taken up, so more water appears on the surface of the gelatine, and at last, when the cell is fully charged, a thin layer of acidulated water is on the top. This water disappears completely during the discharging of the cell, and the discharged cell is as dry as it was before. This process is repeated at every charge and discharge. The gelatinous mass is very elastic, and makes a perfect contact with the electrodes. If the latter develope gas bubbles (at the end of the charge or during over-charging) these bubbles force their way between the plate and the gelatine, pressing the latter back for a moment, and come out on the top of the cell. After the gas bubble has escaped, the gelatine at once touches the plate again and makes contact. This elasticity is one of the most satisfactory features of this gelatinised acid. The resistance of such an electrolyte is greater than that of the fluid dilute sulphuric acid, but the increase is not so important as to be a practical drawback. This will appear from the following tables, containing a charging and discharging of the *same* cell, filled at first with ordinary sulphuric acid (specific gravity 1·850), and afterwards filled with gelatinous acid, made in the manner described above. These numbers represent the average of half-a-dozen tests respectively.

Charging.—(*Cell Filled with Dilute Sulphuric Acid of 1·185 specific gravity.*)

E.M.F.	Amperes.	Hours.	Watt-hours.
1·94	...	...	...
2·08	35	...	...
2·12	30	After ¼ hour.	15·9
2·13	30	„ ½ „	31·87
2·14	30	„ 1 „	63·97
2·14	22	„ 2 „	119·61
2·14	19	„ 3 „	160·27
2·14	14	„ 4 „	190·23
2·14	12	„ 5 „	215·91
2·14	11	„ 6 „	239·45
2·14	8·5	„ 7 „	257·64
2·14	8·0	„ 8 „	274·76
2·14	6·0	„ 9 „	287·60
2·14	6·0	„ 10 „	300·44

This charging was done with a constant E.M.F. between the poles of the cell; and it is preferable to the method of keeping the current constant, because a cell is sooner charged and without developing gas bubbles, which in the other way always begin to appear in the latter part of the charging period.

Charging.—(*Cell Filled with Gelatinous Electrolyte.*)

E.M.F.	Amperes.	Hours.	Watt-hours.
1·84	...	...	...
2·19	34	...	...
2·18	33	After ¼ hour.	18·0
2·18	31	„ ½ „	34·4
2·185	29	„ 1 „	66·1
2·18	25	„ 2 „	120·6
2·18	20	„ 3 „	164·2
2·19	17	„ 4 „	201·4
2·21	13	„ 5 „	230·1
2·19	8	„ 6 „	247·6
2·185	6	„ 7 „	260·7
2·19	6	„ 8 „	273·8
2·19	5½	„ 9 „	285·8

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DISCHARGING.

Ordinary dil. acid (1·185-1·210).			*Gelatinous Electrolyte.*		
Volts.	Starting.	Watt hours.	Volts.	Starting.	Watt-hours.
1·98	...	...	1·895	...	...
1·96	After 1 hour	19·6	1·89	After 1 hour	18·9
1·96	„ 3 „	58·8	1·89	„ 3 „	56·7
1·95	„ 5 „	97·8	1·86	„ 5 „	93·9
1·93	„ 7 „	136·4	1·84	„ 7 „	130·7
1·92	„ 9 „	174·8	1·80	„ 9 „	166·7
1·88	„ 11 „	212·4	1·76	„ 10 „	184·3
1·87	„ 12 „	231·1	...	...	...
1·83	„ 13 „	249·4	...	...	...

Current constant at 10 amperes.

The cell in question consisted of seven positive and eight negative plates, each about $\frac{7}{64}$ of an inch thick; the weight of the plates (with paste) was 27lb., the weight of the electrolyte (in both cases the same weight) 17lb., the whole cell weighing about 46lb.

From the figures given in the tables it will be seen that the capacity of the cell with "gelatinous electrolyte" is only three-quarters of that of the same cell with dilute sulphuric acid. This seems at first a considerable drawback, but looking at the matter more closely it is not so alarming. The diffusion with gelatinised sulphuric acid, goes on slower than in the other case; and this is the reason: if the plates are chosen thinner, say, if 14 positive and 15 negative plates, each only half as thick as before, about one-tenth of an inch, and are put together as elements, the capacity of the cell with gelatinised acid is the same as has been found with the 15 thicker plates in ordinary acid. Practical experience has shown this, and also the reliability of such thin plates. But in fluid sulphuric acid, as it is known, such thin plates have a very limited life, on account of the support of the active material being insufficient. In this way, the resistance of the dry cell is also reduced to the usual figure, and it may be said that the distance between the positive and negative plates can be decreased as far as is necessary to overcome the higher resistance caused by the introduction of the gelatinising substance into the electrolyte.

Another point in connection with the "gelatinised electrolyte" is worth mentioning. It is known that the greater the rate of discharge the less is the available capacity of a cell. For instance, if the same cell which gives 250 watt-hours capacity (discharged with 10 amperes) is discharged with 100 amperes, it will be found to have only about half the capacity. That means that the acid already present *within the active material* is first used up, and *after* this only the acid which comes into the active material by diffusion or transportation of the ions. It can be stated that the accumulator with the greatest amount of acid, mixed with the active material, delivers the heaviest discharges for the longest periods. The utmost porosity of the active material is therefore desirable; but it can only be realised in combination with a solid material of sufficient elasticity to keep the loose powder in its place.

It would seem from these explanations that there is a large field for the use of gelatinised acids in connection with storage batteries. The certainty of working which results from the use of a storage battery has perhaps been the most powerful reason for its introduction in the electric lighting business, and yet this certainty is only relative. Short-circuiting, caused by the dropping out of the active material, has too often been a cause of trouble, not to speak of the breaking of a vessel. Gelatinised sulphuric acid avoids all this. After two years' practical experience no short-circuiting has occurred, and even cells in broken vessels have more than once done service for a week and more.

THE FRAGER ENERGY METER.*

The following is a brief description of the latest form of the Frager meter, an instrument which is largely used by the Paris electrical supply companies. The Frager meter consists of an electro-dynamometer, whose deflections afford a measure of the energy consumed, a clockwork arrangement which registers at stated intervals the energy consumed, and a train of wheels which show on a dial the product energy × time.

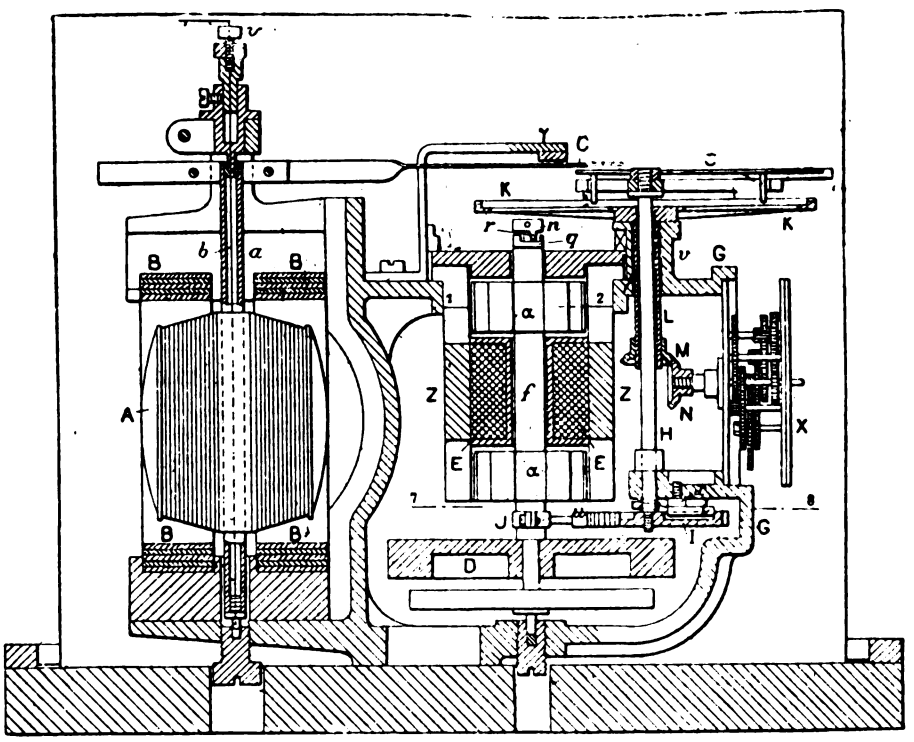

FIG. 1.—Frager Meter.

The electro-dynamometer consists of a fine-wire coil A (Fig. 1) divided into two halves. This coil is suspended from a torsion wire *b*, and is enveloped by the thick wire coil B B, which is wound in the reverse way to A. The torsion wire *b* is kept taut by the adjustable

* From *La Lumiere Electrique*.

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screw *v*, and it is connected to the coil A through the tube *a*, which is rigidly attached to the frame of the coil and to the index needle C. The thick wire coil is in series, and the fine wire coil is in shunt with the lamp-circuit. The action of the fixed coil B upon the movable coil A reduces itself to a couple the moment of which may be expressed in terms of current intensity and a function of the angle between the axes of the two coils. As the moment of the opposing couple is proportional to the angle of torsion, the position of the index needle is a measure of the energy in the lamp circuit.

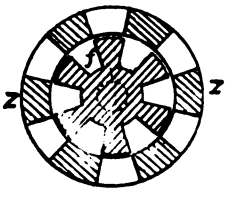


FIG. 2.

The clockwork mechanism is governed by a spiral spring seconds' pendulum, D, whose motion is maintained by electricity. To effect this the arbor *f* of the pendulum is provided with six projections (*see* Fig. 2), and moves freely within the hollow iron core Z of the coil E, which, together, constitute an electro-magnet with poles at *a a*. The coil E is connected at one end direct to the coil A, but the other end is connected to the other end of A through the spring *h* (Fig. 3). The arbor of the oscillating pendulum

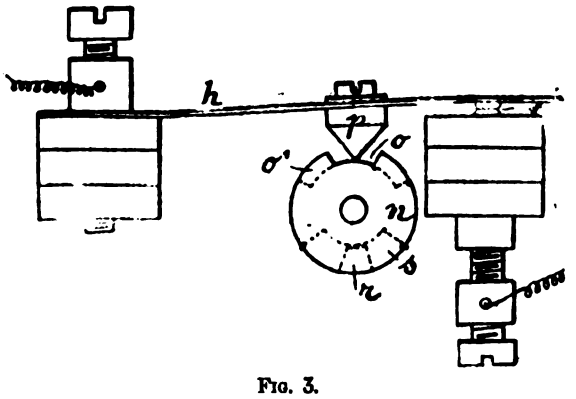


FIG. 3.

terminates in a cap, *n* (Figs. 3 and 4). When *n* is in the position shown in Fig. 3, the pin *p* falls within the notch *o*, and the circuit is completed through the contact *t*. Underneath *n* we have the loose disc *q*. This disc has a notch, *o'*, which is larger than *o*, and a cavity, *s*, in which oscillates the projection *r* (Fig. 4). When the pendulum D is in the middle of an oscillation, the teeth on the arbor, *f*, are in the position shown in Fig. 2, and the pin *p* falls within the notch *o*. As soon as the current passes the arbor rotates say to the right, the pin *p* is lifted out of the notch and the circuit is broken.

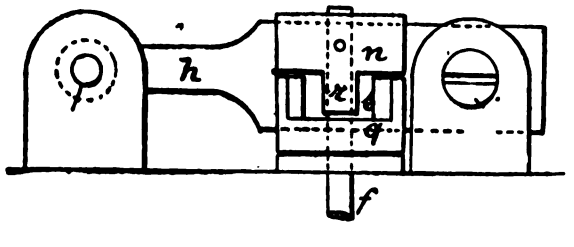
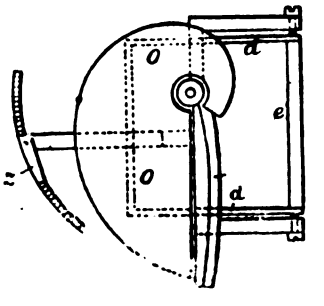


FIG. 4.

When the pendulum is swung back by the spring, the circuit is again closed, and the electro-magnet E gives it another impulse. This goes on until the amplitude of the oscillations is such that the pin *p* strikes against the other end of the notch. The average amplitude of the oscillations is therefore at least equal to the angle subtended by the notch *o*, and as the pin *p* falls within this notch at every half oscillation, the pendulum D receives an impulse every half oscillation. The object of the disc *q* is to prevent the oscillations from becoming too great. In fact, whenever the amplitude is greater than the play of *r* in the notch *s*, the cap *n* carries the disc *q* round with it, and if the amplitude of the oscillations becomes greater than *o'+s*, the ends of the notch *o'* lift the pin *p* and keep the current cut off until the diminution of the amplitude restores the notches to their proper relative positions.

The registering mechanism G (Fig. 1) is governed by the movements of the vertical arbor H, to which is attached the ratchet wheel I. The wheel I is provided with 100 teeth, and is actuated by the paw l J *u*, which causes it to turn through the distance of one tooth at every oscillation of the pendulum. The arbor H makes, therefore, one complete revolution in 100 seconds. At the top of the arbor H, there is a projecting piece which at every revolution lifts the end of the electro-dynamometer needle C against the circular piece *y* (Fig. 1). When the projecting piece passes from under C the needle falls upon the cam O (Figs. 1, 5, and 6) and depresses it, causing its support *d* to turn round *e*, so that the catch *z* being pressed into the notched edge of the wheel K brings it round with the cam O. The rotation of K is transmitted by *v* L M N (Fig. 1) to the counting apparatus X, and as the rotation of K is maintained during the whole period that the end of C rests upon the cam O, this rotation is proportional to the energy consumed. Hence the dial pointers revolve every hundred seconds by an amount proportional to the energy which is being consumed in the house circuit.



FIGS. 5 and 6

When at rest the axis of the coil A makes an angle of 45deg. with that of the coil B B. The scale is, therefore, very open near the position of rest, and the meter is, consequently, very sensitive for a small consumption. By altering the relative position of the two coils, the meter can be adapted to heavy circuits. When the relative exactness of the indications of the meter between the limits which it is proposed to use it have been ascertained, the calibration is completed by increasing or diminishing the number of teeth on the wheel I, according as the meter registers too high or too low, or by changing the wheel N (Fig. 1) the instrument can be converted into an ordinary current meter by merely replacing the coil A by a bar of soft iron.

Underground Telephone System at Berlin.—An extensive underground telephone system is now in course of construction at Berlin, and a large number of cast-iron pipes are being laid by the Telegraph Department for the purpose. The pipes, which are upwards of 25 miles in length, are to carry from 20 to 90 cables, and vary in diameter from 8 to 16 inches. The cables will be sheathed with iron wires, and contain uniformly throughout 28 conductors of No. 19 copper wire, insulated with impregnated fibre, and (to prevent induction or cross talk) lapped with tin foil. The cables now to be laid are over 90 miles in length, and have 2,520 miles of conductors. The cables are supplied by Messrs. Felten and Guilleaume. Man-holes (405 in number) will be placed at certain intervals for the purpose of facilitating drawing in of the cables and testing conductors. This extensive system, it is estimated, will cost about £100,000. It is hoped that when completed it will suffice for the ever-increasing number of subscribers, who already amount to 15,000. Messrs. Felten and Guilleaume, we may add, also supplied the telephone cables at Hamburg, mentioned in our issue of June 27th.

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THE THEORY AND PRACTICE OF ELECTRICAL ENGINEERING.

Of all branches of engineering the electrical enjoys the greatest advantage in the facility with which the principles of pure science can be applied direct to the work without the intervention of arbitrary coefficients and factors of safety which hamper most other professions. The hydraulic engineer, for example, takes the well-known formula for the discharge of water over a weir, and finds that he has to use a coefficient. He may turn to an account of measurements made by two highly skilled experimenters, published some four years ago, and there discover a bewildering page of coefficients according to authorities of every rank. At the end of the volume he will find a sheet of curves, which it is difficult to believe relate to the same thing; the dots through which, or rather among which, the curves are delineated resembling a map of the stars with the path of some eccentric planet that has lost its way. As another example, take the factor of safety of boilers. A factor of six is not unheard of; the Board Trade demand five for marine work; Lancashire boilers are generally made with a factor of four; while the land boilers in France have not shown by the number of accidents that the Government of that country are rash in fixing the factor of safety at three. What would the dynamo builder do if he had to allow such a factor in determining the dimensions of his field-magnets, his armature conductors, or his battery cells?

Electrical science started from the laboratory, and found its way to the workshop; mechanical science was developed for centuries by the empirical engineer, feeling his way from one venture to another, and relying more upon the accumulated experience of his craft than upon any rationalised principles,

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uniformities, or inductions, which are called laws of science, until at last mechanical knowledge was reduced to mechanical science by Prof. WILLIS. It is not surprising, then, that electrical science shows at every point the touch of the theoretical man, and often to so marked a degree as to frighten the non-mathematical mind. The theoretical man is generally, but not necessarily, a mathematician; and until recently a mathematician has been a man who prefers to state a simple fact under the disguise of algebraical symbols, with an apparent love of mystery worthy of the Delphian oracle. The love of mystery is, happily, only apparent; he writes in his own language. The language of mathematics is thoroughly suited to the subject of electricity; and he who can guide his practical work upon mathematical lines will not go far wrong, though it does not follow that he will go in any useful direction or attain any profitable end. Engineers are generally led to some futile paradox, and always to a squabble, when they try to apply too much mathematics to the discussion of the steam engine, the theory of which is much more complicated than that of the dynamo, as its efficiency is less. While the electric engineer uses OHM's law perhaps many times a day, and relies thereon with the utmost confidence, BOYLE's law is a mere text-book matter to the engine builder, who prefers to use a calculated table rather than apply all the corrections and constants which are necessary.

There are some branches of electrical science, on the other hand, in which a very superficial use has been made of theory, the practical development having only received occasional hints from the principles and laws which bear on the subject. Storage batteries are an example of this. We are not aware that there is as yet a unanimity of opinion on the chemical changes which succeed each other in the process of charging and discharging; and it may be hoped that the Paper on this topic which is announced for the Edinburgh meeting of the Institution of Electrical Engineers will place the matter on a sounder scientific footing. Where chemistry and electricity meet there is a danger of falling between two stools; each science is so absorbing in itself that the border land between the two has been too often neglected. Electrolytic processes have been arrived at, generally by purely tentative experiments. Indeed, practice has so far outrun theory in the electric tanning method which we described a few weeks ago, that not even the able chemist who expounded, or rather conversed about it, on the occasion of our visit, could offer any theoretical hypothesis as to the action of the current on the liquor or the hides. Still more recently we were informed that there was no theory to account for the action of the buried rail of the latest electrical tramway, though it would be easier to suggest an explanation in the latter than in the former instance. The great inventor on the other side of the Atlantic has not, so far as we are aware, employed scientific methods of research, nor has he made use of the deductive method in the examination of particular cases, from previous knowledge of the principles of science which govern them. When the practical man goes first, blindly groping perhaps, but with some utilitarian aim, and produces an invention, the theorist takes it in hand, and often increases its value tenfold—witness the beginnings and the development of telegraphy. Nor does the reverse order yield less result, as in the history of the dynamo.

The unique position in which electrical science stands through having first been developed to a very considerable extent by the mathematician before any practical applications of it were made, should give it a firm foundation on which progress may be made with a confidence that no other branch of engineering can enjoy. A sound knowledge of the theoretical quantity of energy of any chemical combination, and the reliance which may be placed on that knowledge, together with a robust confidence in the laws of OHM and JOULE, would enable the youngest member of the profession to meet the wildest statements about lighting the City from a primary battery; and he would have an easier task than if he had to tackle an average inventor of perpetual motion. Unfortunately, our inductions can never be complete, and we never know when we are in possession of all the causes which apparently produce a given effect. Its sure foundation has enabled electrical science to make the more rapid progress; and this progress has brought about changes so great that we cease to wonder at them. Perhaps the worst evil that has resulted from this state of things is the advantage which has been taken of it by unscrupulous speculators in offering alluring baits to ignorant investors, for whom no wonder can be made too great to be swallowed if sufficiently flavoured with electricity.

OBITUARY.

LADY PENDER.

Great sympathy will be felt for Sir John Pender in the bereavement which he has sustained by the death of Lady Pender, who died on the 8th inst., after a very short illness. The loss will be deeply felt in the wide circle where her influence was felt. She was the daughter of the late Mr. H. Denison, of Daybrook, Nottinghamshire, and was the second wife of Sir John Pender, to whom she was married in 1851.

REVIEWS.

"Traité Th orique et Pratique des Machines Dynamo-Electriques." By R. V. PICOU. (Paris: Baudry et Cie.)

To give a complete theoretical and practical treatise of dynamo ma nines within the limited space of some 300 pages is obviously mpossible, and we need therefore not be astonished to find that the author of the book under notice has failed to carry out, in the strict sense of the word, the promise conveyed by the title. Nevertheless, he gives a good deal of theory and also some practical hints, though of the latter we should have been glad to see more. The author's position, as late engineer and present consulting engineer to the Paris Edison Company, must have given him and still give him exceptional opportunities of gaining information of a practical character; but at the same time it is easy to understand that, occupying the position he does, he cannot be expected to tell the reader all he knows on the subject; and this is, perhaps, the reason why the book, taken as a whole, is rather of a theoretical than of a practical character. But even theoretical books may be of practical use, and the work in point belongs to this class. It is certainly the best book on the dynamo which has as yet been published by a French author.

The book is divided into six parts, treating of the following subjects:—Elementary Matters in Connection with Electricity and Magnetism, Ideal Machines, Description of Machines as Actually Made, the Magnetic Circuit, Direct-Current Dynamos, Alternators. There is also an appendix treating of absorption and transmission dynamometers.

The chapters in which the author gives the elementary equations required for the study of dynamo-electric machinery form a kind of résumé of the matters usually found in text books, but no attempt has been made to show the connection between these equations and the ordinary mechanical laws familiar to engineers generally. Nearly all books which have

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as yet been published on the dynamo fail in this respect. The authors seem to think it quite sufficient if they give the various equations for electro-magnetic relations which may be found in every text book, and leave the reader to find out, the best way he can, the why and wherefore of these equations and the manner of their practical application. To return, however, to the work under notice, those chapters in which dynamo machines are described might with advantage be enlarged. We miss nearly all the important English and German machines, while space is unnecessarily taken up with such obsolete machines as the Wilde, old Gramme, old Siemens, and Weston. There is, however, a fairly exhaustive description of the Desrozier machine, upon which no detailed information has hitherto been available. As regards alternators, the machines described are also mostly obsolete. We find here the old Alliance, Wilde, Siemens, and the very first type of Ferranti machine. Of modern machines the Zipernowsky and Westinghouse are the only examples cited, and their description is very meagre. Notwithstanding Mordey's experiments, the author still inclines to the opinion that iron in the armature of an alternator is necessary for parallel running.

After these descriptive chapters follow some on the magnetic circuit, on a general theory of dynamos, and on armature reaction, which doubtless constitute the best part of the book. Hopkinson's and Ewing's investigations are here summarised, and the author also gives some of his own results relating to hysteresis. The apparatus employed by him consisted of a wire coil, into which were inserted successively the different samples of iro to be investigated. An alternating current, which by me ıs of a rheostat could be kept of the same strength, was se through the coil, and the expenditure of energy was read off a watt meter. Unfortunately, the figures obtained are not directly comparable with those obtained by Hopkinson and Ewing, because Picou employed straight short cores, for which it is very difficult to determine the induction, which, moreover, must necessarily vary throughout the mass of the sample. It would in this respect have been better to employ samples of closed ring shape. The results have, nevertheless, considerable interest, as giving comparative values of the energy lost by hysteresis and eddy currents. The author has also investigated the effect of a change in frequency, and finds that in a particular case the hysteresis and eddy current loss is doubled when the frequency is trebled. Assuming that the hysteresis loss per cycle is independent of the frequency, he is thus able to separate from it the loss by eddy currents.

The author's theory of the dynamo is, as he states himself, a digest of the work done in this direction by Hopkinson, Kapp, Forbes, and Ewing. In developing the use of characteristic curves the author has, however, gone further than his English colleagues; and this part of the book will prove very useful. The application of theory to the designing of machines is shown by examples, and in selecting these the author has done his best to make his book useful to practical men.

ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 230.)

§ 3. **Ganz Alternator.**—Proceeding, then, more particularly to describe the elements of the system, we take first the alternator, or alternating dynamo. The most recent type of Ganz machine, called the A type, is an alternator of that class in which the fixed or stationary electro-magnetic portion constitutes the armature, and the revolving portion the field-magnet. In Fig. 2 is shown a perspective view of the alternator, and in Fig. 3 face and end elevations. The field-magnet is a stellate electro-magnet, keyed on the steel shaft, which is the driving shaft. In the smaller sizes this shaft carries the usual pulley for belt or ropes keyed on outside the two massive bearings which are erected upon the bed-plate. A reference to Fig. 3 will also show how this stellate magnet is constructed. A number of V-shaped sheet-iron stampings (Fig. 4, *a*) are punched out and built up with interposed laminæ of paper into the cores, which are bolted in between two iron hubs or rings keyed into the shaft. These cores project like the stout spokes of a rimless wheel, and over them are slipped the magnet bobbins wound on split zinc frames. The bobbins are kept in position on the cores by a head or cap of gun-metal, which fits on the end of the laminated magnet core, and is firmly secured to it by a traversing bolt.

The magnet poles are even in number, varying from 6 to 40 according to the size of the machine, and are alternately north and south poles. Surrounding this stellate magnet is the ring-shaped armature frame, formed of two massive iron rings kept apart by distance pieces and bolted together. This armature frame carries on its inner circumference the armature coils. These, like the field-magnets, consist of cores built up of sheet-iron stampings, T-shaped (Fig. 4, *c*), which are held together by bronze press-plates and by bolts. On to these cores are slipped the armature bobbins, which consist of vulcanized fibre

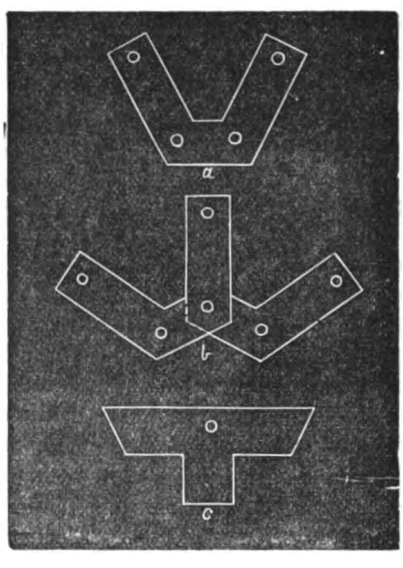

FIG. 4.—V and T-shaped Iron Stampings for building up field-magnet and armature cores.

frames, wound over with highly insulated wire. These bobbins are joined up in series in such manner that the currents induced in each are in the same direction, and generally one half of the armature coils is put in parallel with the other half, the individual coils in each half being joined in series. In like manner the several magnets of the field-magnet are divided into two sets, the magnet coils in each set being in series, and the two sets being joined up in parallel. The clearance between the polar faces of the field-magnets and the armature-magnets is very small. Each armature section is thus complete in itself, and can be removed or replaced in a few minutes. The armature sections are screwed to the distance-pieces of the main ring frame, but insulated from them by intervening insulating pieces. In building up the stellate electro-magnet core one layer of the V-shaped iron stampings is first arranged in the proper angular positions; another layer is then laid over them, with paper between, but so that the individual stampings of the second layer "break-joint" with those of the first, and the process continued until the proper thickness is obtained (*see* Fig. 4, *b*). Strong iron press-plates are then bolted up so as to compress all this mass of laminated iron into a star-shaped magnet. The bobbins having been put on the cores, the slightly projecting ends of the cores are fitted with bronze bobbin-holders, held on by a bolt which traverses the laminated pole, in order to prevent the bobbins from being thrown off when the magnet revolves.

* This series of articles is a continuation of those which appeared in *The Electrician* under the title of "The Alternate Current Transformer," by the same Author, and which have since been largely extended and republished in book form. All rights are reserved.

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In some of the larger sizes of machines the annular armature frame is made to slide along the bed-plate in guide slots by means of a screw By this means the whole armature can be moved along laterally, so as to move it off the field-magnet, and enable this latter to be got at easily for repairs. The machines are made either to be auto-excited or separately excited. In the former case the excitation of the field-magnets is effected by a rectified alternating current. This current is supplied from the secondary circuit of a subsidiary transformer, whose primary is fed from the armature. The alternating current is rectified by means of a commutator keyed upon the shaft of the dynamo. This commutator is made in the following fashion:—On an insulating hub are arranged brass or copper cylindric sections, as many in number as the poles of the stellate field-magnets. These metal segments are insulated from each other, and separated by narrower metal sections insulated on both sides from the main sections. (*See* Fig. 5, in which the thick black lines represent the insulating portions

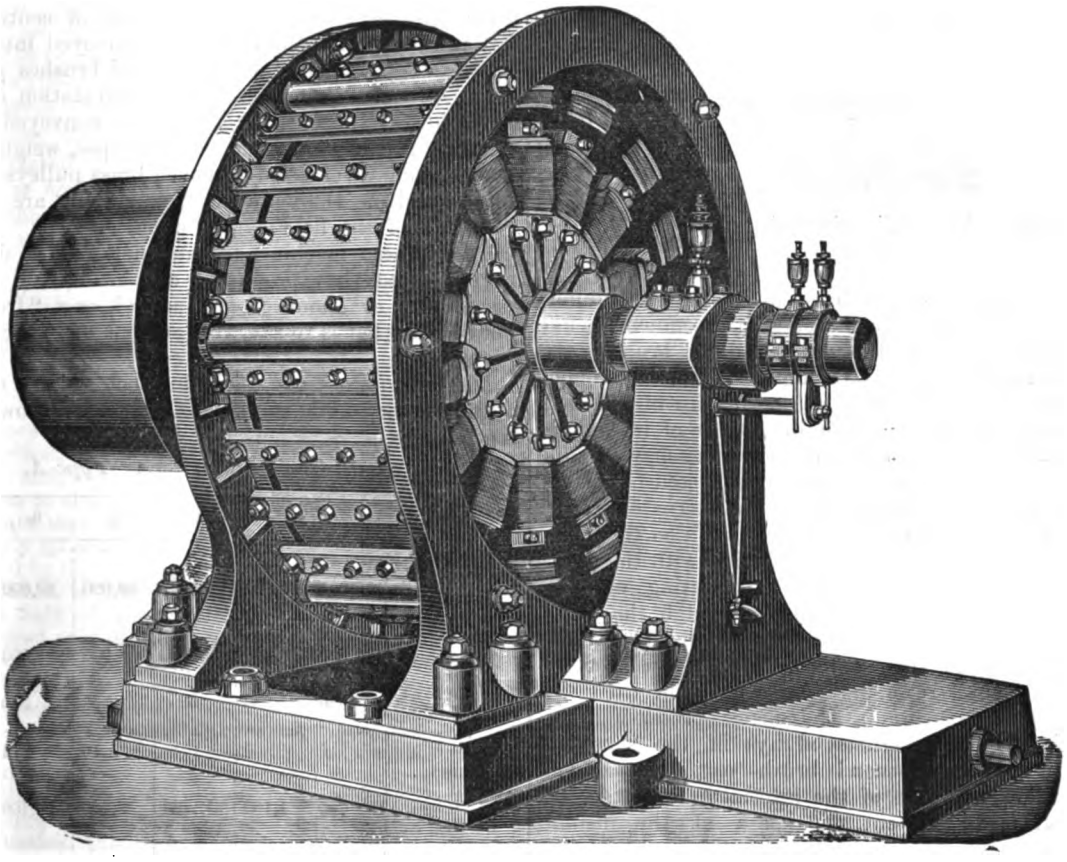
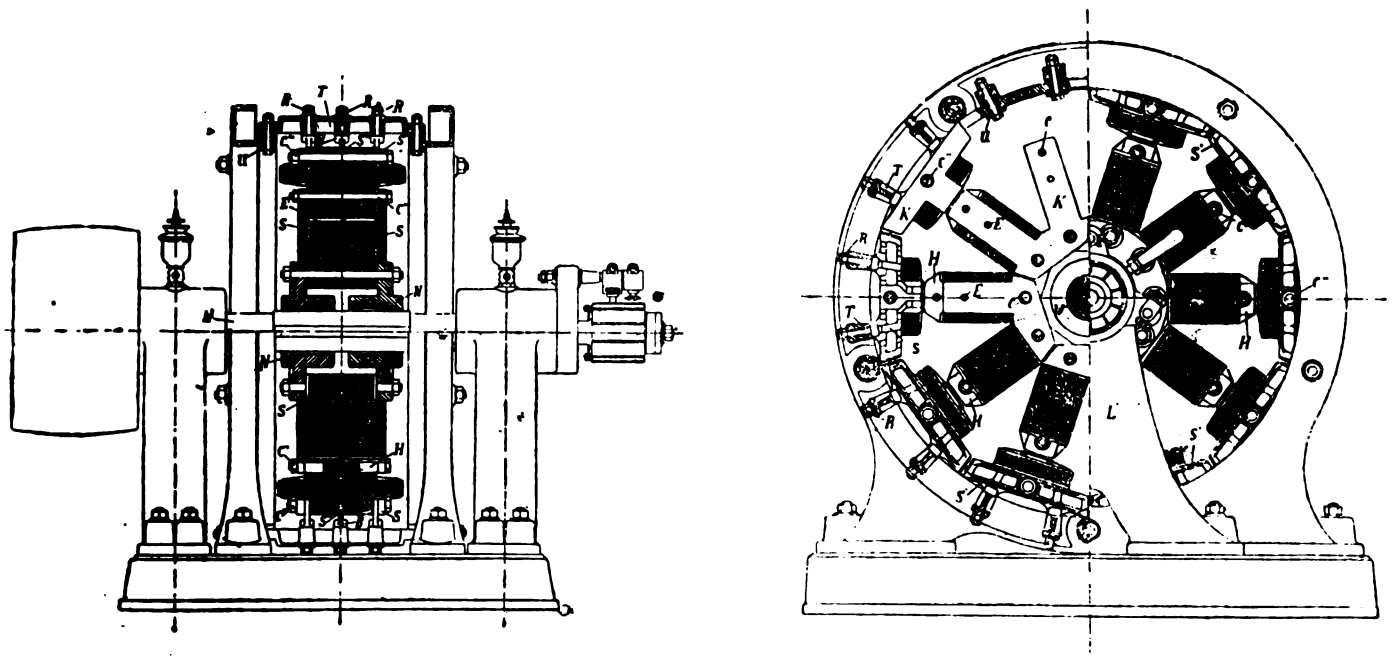


Fig. 2.—Ganz Alternator (Zipernowsky, Déri, Bláthy) 50 Kilowatt.



Figs. 3.—End and Face Elevations of Ganz Alternator.

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(mica). The narrower sections are all connected together, and the wider sections are also so connected that alternate large sections are in conducting contact.

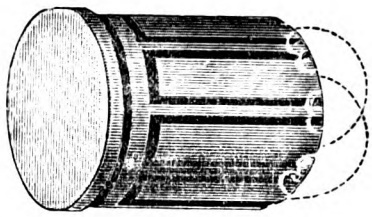

FIG. 5.—Commutator for rectifying alternating currents on Ganz Alternator.

In Fig. 6 we imagine the cylindrical surface of the commutator rolled out flat, the connections between the segments being represented by the firm and dotted lines. The brushes are represented diagrammatically in an oblique position. On opposite sides of the commutator there are two pairs of brushes, one brush at each side being a little in advance of its fellow. One set of the wide sectors, of which a member may be supposed to be in contact with one brush, is connected to the extremities of the field-magnet circuit; and the alternate sectors, one member of which is in contact with a brush on the opposite side of the commutator, are in connection with the other end of the field-magnet circuit. The alternating exciting current enters by one brush and passes through the field-magnet coils. As the electromotive force of the field transformer falls to zero and then reverses sign, so the sectors pass under the brushes, reversing the connection with the ends of the field-magnet circuit, and hence preserving the current through the field-magnets always in the same direction. The use of the second brush on each side in advance of its fellow, and also of the intermediate sectors on the commutator, is to prevent the spark at the instant when the brushes change sectors; and this is achieved by connecting through a little resistance the brushes on the same side of the commutator, one being a little in advance of the other, by an amount sufficient to place the one brush on the intermediate or neutral sector at the instant when its fellow steps off the "live" sector just behind it. At the instant, then, before the change of connection is made by the brushes leaving their respective sectors they are short-circuited

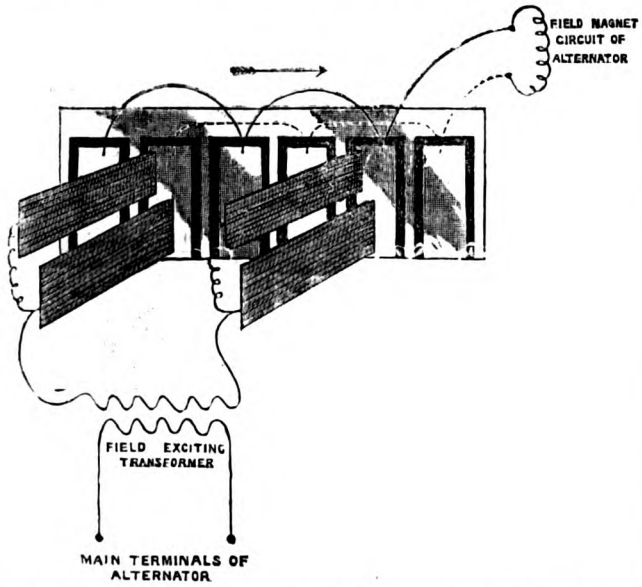

FIG. 6.—Diagram representing action of Commutator on Ganz Alternator.

by reason of the fact that their companion brushes are on the intermediate sectors, which are all in conducting connection. Hence the sparking, which would otherwise exist, due to the self-induction of the field-magnet circuit, is kept under, and the wear of the commutator greatly improved. This same device of a pair of brushes, one having a lead over the other to stop sparking, is employed in the Ganz alternating motor. (See *Electrician*, Vol. XXIV., p. 453, 1890.) The larger sizes of the Ganz alternators are not self-exciting, but are excited by a continuous current from a separate exciting dynamo. In the smaller sizes (150 horse-power) of central-station alternators the magnetising current is conveyed into the alternator by means of copper contact rings and brushes pressing against them. In the larger sizes of central-station alternators (600 horse-power) the exciting current is conveyed into the alternator by a pair of flexible copper ropes, weighted at one end, and hanging over deeply-grooved brass pulleys insulated from, but carried on, the main shaft, and which are respectively the terminals of the field-magnet circuit.

In all these machines the magnets are so designed that at normal speed they produce a current having 5,000 reversals per minute, or about 83 per second, or a "frequency" of 42 per second, that is to say, the current has 42 complete periods per second.

The alternators are made in about eight sizes, varying in output from 10,000 to 380,000 watts, as shown in the following table:—

Ganz Alternators.—Type A.

Number	1.	2.	3.	5.	6.	7.	8.
Maximum output of dynamo in watts.....	10,000	20,000	30,000	50,000	80,000	160,000	380,000
E.M.F. at terminals in volts ...	1,000	2,000	2,000	2,000	85,000	5,000	5,000
Revolutions per minute	830	830	625	500	360	170	125
No. of poles on field-magnet ...	6	6	8	10	14	30	4
Weight of machine in kilograms.	700	1,100	1,700	3,400	6,100	11,000	23,000
Maximum output of dynamo in watts.....	9,650	19,300	28,950	48,250	77,200	154,400	366 00
Horse-power required to drive dynamo at full load ...	15·6	29·8	44·1	76	120	233	550

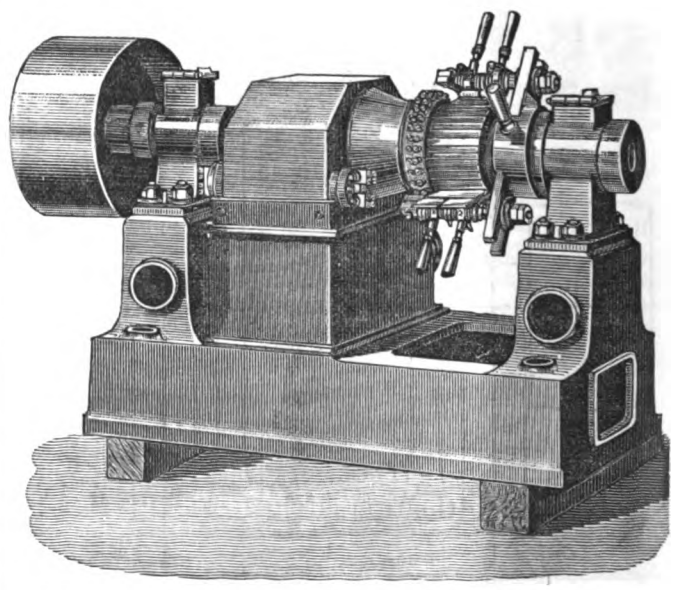

FIG. 7.—Continuous-current Exciter Dynamo, by Ganz.

The values here given for output and absorbed power are taken from catalogue figures, and must not, therefore, be regarded as having the weight and accuracy which might be expected from careful independent tests. They are here given merely for the purposes of general comparison.

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The exciting dynamos employed in connection with the larger sizes of machines are ordinary drum-armature shunt dynamos supplying current at about 100 volts. The field-magnets are of the well-known form of vertical single horse-shoe type, and are illustrated in Fig. 7, and call for no special remarks. In some cases of central-station work the exciters are direct-driven by coupled engines, and in other cases they are driven by a belt off the alternator shaft. The general practice is to cause two or three alternators to feed into a pair of mains which supply the field-magnet circuits of the alternators arranged in parallel across them. By this arrangement a breakdown of one exciter does not interrupt the maintenance of the fields of the alternators.

(To be continued.)

THE ELECTRO-DEPOSITION OF PLATINUM.*

BY WM. H. WAHL.

The permanence and unalterability of the metal platinum have suggested its application as a protective covering upon the surfaces of other metals; and, even in the early days of the art of electro-deposition, efforts to obtain a satisfactory coating of this metal were made. The results that have been accomplished cannot be said to have been entirely satisfactory—a statement which, I believe, will be fully sustained by the fact that electro-plating with platinum, on the commercial scale, is practised only to a very limited extent. When the wide field of application for platinum-plating is considered—and I need only name philosophical, engineering, surgical, dental, and electrical apparatus and instruments, fire-arms, watch-cases, and jewellery, to say nothing of the host of miscellaneous articles of utility and ornament to which the metal could be advantageously applied—the conclusion is irresistible, that the processes thus far proposed for the purpose do not fully meet the requirements of practical service.

Thus far, of all the methods that have been proposed for electro-plating with platinum, three only appear to have sufficient merit to deserve special notice; these are:—

(1) Roseleur-Lanaux method, based on the electrolysis of a solution of the double phosphate of sodium and platinum.

(2) The process of the Bright Platinum Plating Company (of London), a modification of that of Roseleur, involving the introduction into the bath of certain substances, such as sodium chloride and borax, to ensure a bright deposit of the metal; and

(3) Boettger's method, founded on the electrolysis of a solution of the double chloride of ammonium and platinum in sodium citrate.

Each of these baths will yield satisfactory results for a time; but, as I shall endeavour to show, the peculiar difficulties met with in the practice of platinum-plating render it impossible to maintain the chemical integrity of these electrolytes, and, in consequence thereof, they soon become inefficient or inoperative by reason of contamination with the secondary products formed therein.

The first difficulty encountered is that of obtaining a bright, reguline and adherent deposit of the metal, in which form only it will answer the demands of practice. There is no difficulty in effecting the separation of the metal from solutions of almost any of its compounds. Zinc, iron, and tin reduce it promptly by simple immersion, and this very facility of reduction is one of the reasons why, even by the method of electrolysis, the desired object is frequently accomplished only in an imperfect manner; for the electro-plater is obliged to meet and overcome its obstinate disposition to separate from many of its compounds in the condition of platinum black, lacking coherence and adherence, and therefore entirely unsuited for his purpose.

Another, and no less serious difficulty, arises from the insolubility of plates or sheets of this metal as anodes, where solutions containing platinum salts are submitted to electrolysis. In electro-plating with copper, silver, gold, and nickel, but little difficulty is encountered in practice on this account, since anodes of these metals are freely soluble in many solutions capable of depositing them when they are submitted to electrolysis, and the rate at which these anodes are respectively dissolved approximates so nearly to that at which the metals are deposited upon the objects at the cathode, that the metallic strength of the electrolyte is maintained substantially uniform, and electro-plating solutions of these metals may be operated for a long time without requiring additions of metallic salts. The electro-deposition of the metals whose anodes are thus tractable is carried on industrially with success.

It results from this want of solubility of the anode that the metallic strength of the electrolyte employed is continuously being weakened, while the deposition of the metal is going on, and the conductivity of the bath is being continually modified thereby. The character of the deposited metal also is injuriously influenced by these constant alterations of condition in the bath; and, as the rate of deposition becomes slower and slower by reason of the gradual impoverishment of the metallic strength of the solution, it will be necessary to restore it by fresh additions of metallic salt. The practice in all the processes of electro-plating with platinum employed up to the present time, save that of Boettger, is to use for this purpose the tetra-chloride of platinum. With this single exception, all the solutions for the electro-deposition of platinum thus far made known, so far as I am aware, are made by treating the chloride with compounds of the alkalies, soda, potassa, or ammonia. Of these, the phosphates and oxalates of soda, or potassa, are in greatest favour, and a number of formulæ for preparing platinum-plating baths with their aid have been described. The resulting substance is commonly a double salt, such, for example, as the double phosphate of sodium and platinum; the double oxalate of potassium and platinum, &c., contaminated, however, in each case by the chloride of the alkali employed, which is formed from the decomposition of the platinic chloride. As often as it is found necessary to strengthen the bath, fresh additions are made of platinic chloride, which, by chemical interaction with the constituents of the bath, aided by the process of electrolysis, yields more alkaline chloride; and it follows that the bath, by reason of becoming surcharged with this foreign substance, and with other secondary products of electrolytic decomposition, ceases to yield bright, reguline platinum upon the articles to be plated therewith and must be discarded. It then becomes necessary to regain the platinum contained in the discarded bath by one or another of several processes of reduction known to chemists. The platinum thus regained may be converted into chloride and utilised in the preparation of a fresh bath, with which the same series of operations will be repeated. Boettger purposes to maintain his bath by fresh additions of his original solutions, but it must be apparent that the continued electrolysis of such a solution as he employs must be attended with the constant accumulation therein of alkaline chlorides from the same causes as those specified above. This rapid deterioration of the baths, therefore, involves their frequent renewal at the expense of time and labour, so that, in spite of the fact that there is a wide field for its application, it is principally for this reason that the art of electro-plating with platinum on the commercial scale has thus far been practised only to a very limited extent.

It was therefore necessary to devise some plan for overcoming the difficulties herein described; and, after making a number of fruitless experiments, I was so fortunate as to find a plan which appears to offer a solution of the troublesome problem of electro-plating with the group of metals, whose anodes are insoluble, in a more satisfactory manner than any other that has hitherto been suggested.

The plan here referred to consists in employing platinum hydroxide for the purpose of maintaining the metallic strength of the plating-bath. For this purpose, the hydroxide, which is readily soluble in alkalies and in many of the acids, may be introduced into the plating-bath from time to time and dissolved therein by stirring, or it may be permitted to remain in the bath in excess, the undissolved portion remaining at the bottom of the containing vessel, or it may be suspended in a canvas bag adjacent to or surrounding the anode of carbon, according as the nature of the electrolyte may indicate one or the other method to be the preferable one. As the solutions which yield the best results in plating are those of the oxygen salts, I have found it advantageous also to prepare these directly from the hydroxide. This method, I have found, is capable of yielding a number of electrolytic baths of platinum that will maintain their metallic strength approximately unimpaired during electrolysis, and without the objectionable features of introducing into them substances that will cause them to deteriorate by the accumulation therein of injurious secondary products of decomposition, as is the case where such baths are maintained by additions of platinic chloride or alkaline chloro-platinates, as has hitherto been the invariable practice. Referring now specifically to the properties that render the platinic hydrate useful for the purposes above indicated, the following points appear to be deserving of mention.

It is readily soluble in aqueous solutions of the alkaline hydrates, and in a number of acids, mineral and vegetable. In the treatment of the platinic hydrate with aqueous solutions of the alkaline hydrates, the former plays the part of a weak acid, forming compounds known as platinates, which are very soluble, and from which the platinum is not precipitated on the addition of an excess of alkali. A weak aqueous solution of sodic or potassic hydrate (but especially the last named) will dissolve a large quantity of platinic hydrate, at the ordinary temperature, though solution takes place more freely when heat is applied. These solutions have the advantageous features of being freely conductive of electricity, and of yielding bright, reguline, and adherent electro-

* Read at the meeting of the Chemical Section of the Franklin Institute, Philadelphia, May 20, 1890.

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deposits of platinum on metallic surfaces previously prepared to accept the same. Furthermore, with a current of moderate strength, the platinic hydrate only is affected, as is shown by the pronounced evolution of oxygen at the anode and by the total absence of gas at the cathode. Also, it is manifest from the free solubility of platinic hydrate in alkaline hydrate, even in the cold, that if free platinic hydrate be present in a bath of alkaline platinate, the alkali set free in the process of electrolysis will combine with this platinic hydrate to form fresh platinate. For this purpose it will be necessary either to have present in the bath at all times a small excess of platinic hydrate which may remain upon the bottom of the containing vessel, without interference with the plating, and which may be replenished from time to time; or, to introduce at the end of the day's work, a quantity of the platinic hydrate sufficient to restore the metallic strength of the bath to normal, assisting the solution of the metallic hydrate by stirring, and if necessary by the application of gentle heat. As I have found that the platinate solutions act best when they contain a considerable excess of free alkaline hydrate, being more conductive of the current and yielding the platinum more freely and in the best condition, the addition of the proper quantity of platinic hydrate at the close of the day's work in the case of a bath of considerable volume, or the addition of small quantities at intervals, in the case of a small bath, will be found to answer the desired purpose of maintaining the metallic strength of the bath approximately normal for an indefinite period. In a bath where considerable free alkali is present, the platinic hydrate added as just indicated dissolves very freely even in the cold. The important fact is to be noticed, that the alkaline platinate solutions may be maintained and operated for a long time in the manner described, since no deleterious secondary products are formed by electrolysis to vitiate and render them inoperative, as will speedily be the case where the platinic chloride is used for this purpose. The mineral acids (hydrochloric, nitric, sulphuric, and phosphoric acids), dissolved the hydroxide freely, as likewise do certain of the vegetable acids, notably oxalic acid, and form with corresponding salts of the alkalies, double salts, many of which are soluble in water. Of the salts thus capable of being formed, however, so far as I have been able to determine by experiment, only a limited number appear to be adapted to yield a deposit of bright, reguline and adherent platinum. The halogen compounds may obviously be prepared more conveniently by the direct solution of the metal in *aqua-regia* than by the method I have described; but as I have found the oxygen compounds of platinum to yield much more satisfactory results, I therefore exclude them from consideration.

(To be continued.)

CONTRIBUTIONS TO THE MOLECULAR THEORY OF INDUCED MAGNETISM.*

BY PROF J. A. EWING, F.R.S.

After referring to Maxwell's discussion of Weber's theory, which ascribes magnetisation in iron and other magnetic metals to the turning of molecules which are already permanent magnets, and to suggestions made by Profs. Wiedemann and Hughes, and lately by Mr. A. E. Kennelly,† the writer describes experiments which he has made directly bearing upon the molecular theory. The experiments were made by grouping near to one another a large number of small permanent magnets, each pivoted on a fixed centre, and by studying the manner in which the configuration of the group changed when external magnetic force was imposed. The results do not support the notion that the molecular magnets form closed chains in unmagnetised iron. They lead, however, to the important conclusion that no arbitrary conditions of directional constraint need be postulated to make the manner in which the molecular magnets turn agree with the chief features of magnetic quality. In the writer's view the molecular magnets are perfectly free to turn in response to external magnetic force, except in so far as they are constrained by the magnetic forces which they exert upon one another. He discusses this theory in a preliminary manner with regard to the form of the magnetisation curve, the character of cyclic processes, the effects of temperature, of vibration, of stress, and so forth, and shows that it is in general agreement with the known facts. The summary of conclusions is as follows:—

I. That in considering the magnetisation of iron and other magnetic metals to be caused by the turning of permanent molecular magnets, we may look simply to the magnetic forces which the molecular magnets exert upon one another as the cause of their directional stability. There is no need to suppose the existence of any quasi-elastic directing force, or of any quasi-frictional resistance to rotation.

II. That the intermolecular magnetic forces are sufficient to account for all the general characteristics of the process of magnetisation, including the variations of susceptibility which occur as the magnetising force is increased.

III. That the intermolecular magnetic forces are equally competent to account for the known facts of retentiveness and coercive force, and the characteristics of cyclic magnetic processes.

IV. That magnetic hysteresis and the dissipation of energy which hysteresis involves are due to molecular instability, resulting from intermolecular magnetic actions, and are not due to anything in the nature of frictional resistance to the rotation of the molecular magnets.

V. That this theory is wide enough to admit explanation of the differences in magnetic quality which are shown by different substances, or by the same substance in different states.

VI. That it accounts in a general way for the known effects of vibration, of temperature, and of stress, upon magnetic quality.

VII. That, in particular, it accounts for the known fact that there is hysteresis in the relation of magnetism to stress.

VIII. That it further explains why there is in magnetic metals hysteresis in physical quality generally with respect to stress.

IX. That, in consequence, any (not very small) cycle of stress occurring in a magnetic metal involves dissipation of energy.

* Abstract of Paper read before the Royal Society, June 19, 1890.

† *The Electrician*, June 6 and 13, 1890.

UNDERGROUND MAINS IN PARIS.

In our issue of July 12, 1889, we gave some particulars with regard to the system of underground mains employed in Paris by the Compagnie Continentale Edison, and more recently (*The Electrician*, Feb. 7, 1890) we described the system used by the Municipality.

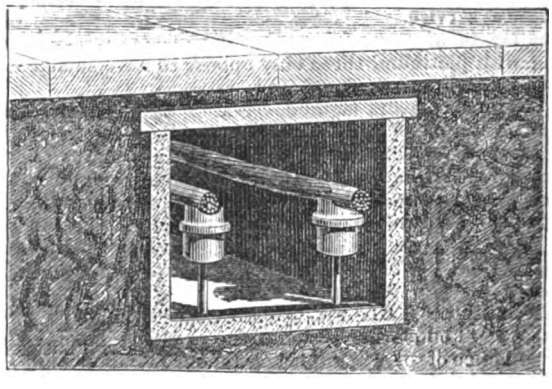

FIG. 1.—Underground System of the Société de la Transmission de la Force par l'Électricité.

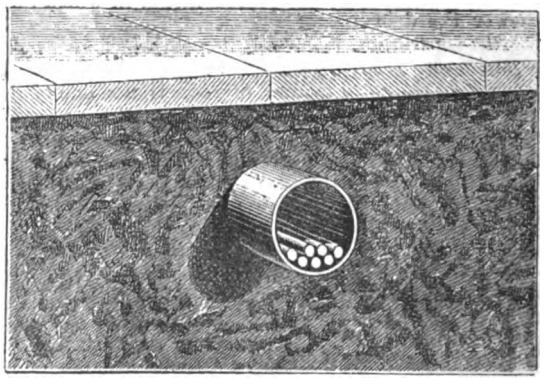

FIG. 2.—Underground System of the Popp Company.

The accompanying figures illustrate the methods adopted by two other companies engaged in the electric lighting of Paris. The Société de la Transmission de la Force par l'Électricité have at present three central stations, but these will shortly be converted into distributing centres fed from the main station at St. Ouen. A high-tension continuous current from St.-Ouen will drive motors in the sub-stations, the motors in their turn driving low-tension dynamos. The mains of this Company are of bare copper wire,

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and are supported on porcelain insulators situated in cement conduits as shown (Fig. 1). The conductors are kept on the insulators by galvanised iron cross-pieces. The Compagnie Popp employ iron pipes 20 cm. in diameter (Fig. 2). These pipes are provided with flanges, and the lengths are bolted together, a ring of india-rubber being placed between the two flanges as they are screwed up. The cables, which are insulated, are drawn in in the ordinary way. We are indebted to *l'Électricien* for the above particulars and illustrations.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS.—THURSDAY, July 3rd.

Central London Railway Bill.

The Select Committee of the House of Lords, presided over by Lord Henley, resumed the consideration of this Bill on Thursday, when further evidence was taken in support of the case for the promoters.

Colonel HEYWOOD, engineer to the Commissioners of Sewers of the City of London, examined by Mr. Saunders, Q.C., said he did not know what would have happened at Cheapside if Victoria-street had not been made. Notwithstanding the formation of that street, as well as of Cannon-street, and the increased number of passengers carried by the railways, the traffic in the streets of the City was increasing rapidly, and causing great public inconvenience.

Mr. H. P. GILBEY (senior partner of Messrs. W. and A. Gilbey, the Pantheon, Oxford-street) said that in his opinion the proposed railway would be of the greatest possible advantage to those carrying on business in Oxford-street, as it would relieve the congested traffic of the street. The Committee again adjourned.

FRIDAY, July 4th.

Sir JOHN FOWLER, one of the engineers to the proposed railway, was examined by Mr. Pember, Q.C. There would be no damage done to St. Paul's Cathedral by the construction of the railway. He considered the capital sufficient; the railway would be cased in iron, and about 70,000 tons of that metal would be used. As there might be a fluctuation in price of £3 or £4 a ton, it was necessary to have a considerable margin of capital. He did not think the margin was too large. He was very anxious in this case to have sufficient capital, in order to avoid that which had damaged so many other undertakings.

Sir FREDERICK BRAMWELL also gave evidence in support of the Bill.

MONDAY, July 7th.

The Committee on this Bill resumed their inquiry at the House of Lords on Monday, when Mr. Joseph Keech Aston (secretary and treasurer to Queen Anne's Bounty), Mr. Binnie (surveyor to the County Council), Mr. W. Malleson (carrying on business near Holborn-viaduct), and Sir George Bruce (past President of the Institute of Civil Engineers), gave evidence. Mr. Bidder, Q.C., and Mr. Cripps, Q.C., addressed the Committee, which afterwards adjourned, in consequence of the illness of Lord Rowton, one of the members.

The Telephone Companies.

The DUKE of MARLBOROUGH called the attention of the House to the fact that the period within which Her Majesty's Government can serve notices to terminate the existing licences to the National Telephone Company expired at the end of last month, and to move—"That in consequence of the recent declaration of the Postmaster-General, in another place, that the Post Office do not intend to undertake the work of the telephone as a branch of that department, it is advisable that licences be granted to responsible parties who will be willing to undertake the business of forming new telephone companies on the expiry of the present patents owned by the National Telephone Company; and that competition is advisable in the interest of the public in order that the present exorbitant rates may find their proper level." The noble Duke said that, in answer to questions he had put in that House, the Marquis of Salisbury had said that the matter was one of great public importance, and that it would be considered at some time during this year, and afterwards the noble marquis had said that the matter was under the consideration of the Government, who had not come to any decision as to the line they would adopt. Subsequently, in the other House, the Postmaster-General was asked whether the Government intended to exercise their powers to buy up the licences and the telephones; and the answer was that the Government had no such intention. The question arose whether the admission of the Prime Minister that the matter was one of great public importance did not call for some further statement on the part of the Government. Their lordships must be more or less familiar with the uses to which telephones could be and were applied. There were telephones in nearly every considerable town on the Continent. In Paris there must be three or four times as many subscribers to telephones as there were in London. The comparative absence of telephones in London was partly due to the amount of money paid for patents and in the formation of companies, and partly to the want of facilities for extending the operations of the companies. When the telephone was first introduced the Company owning it obtained a peculiar licence from the Government. It was a licence for 30 years to carry on business under certain restrictions and regulations, and the Government reserved the power to buy up the interests of the companies every seven years on giving a prescribed notice. The Company agreed to pay to the Post Office a royalty of 10 per cent. of their gross receipts, and the Company undertook that they would neither sell nor assign nor dispose of their powers without the consent in writing of the Postmaster-General. Any difference of opinion between the Government and the companies as to the valuation of their property was to be settled by arbitration; and the valuation was to include powers, privileges, works, and other property, but nothing was said as to plant, goodwill, or unearned increment. As the Government did not give the prescribed notice on June 30 last, to expire on December 31, it would now be December, 1897, before they could acquire the telephones. No one with any practical experience would venture to say what the Government might be called upon to pay, whether it would be one million or four millions. It would be a public benefit if the Government would acquire the whole telephone system at a cost of two or three millions, so as to enable them to enlarge the facilities for inexpensive telephonic communication; but as the Government would not do this, the public must look to the present companies. The United Telephone Company, which obtained the licence from the Government, had paid high dividends, and they had pooled their interests with other companies. This company possessed all the Bell patents, for which they paid £370,000. The Company formed subsidiary companies—the Lancashire and Yorkshire, the National, and one or two others—each of which had its own capital. When the telephone was proved to be a success, the shares of the United Company went up from £5 to £15; and the shares of the subsidiary companies, in which the original company had large holdings, also advanced considerably. A remonstrance was issued by the Postmaster-General against these transactions, which was in direct contravention of the clause in the licence against the sale or assignment of the Company's interests. The charge for a telephone in London was £20 a year, whereas the average charge for one in all the European capitals was £6 a year, and the English telephones being connected with single wires only were so subject to inductive and other disturbances that they were practically useless. To make them of real value they should be worked by means of double wires. If the houses in the West End had a good telephone service it would save an enormous amount of correspondence; but in order to obtain an efficient service there ought to be competition. In the face of the agreement that the Postmaster-General had entered into with the National Telephone Company it would be most unfair, most unjust, and most improper for his department to enter into competition with the existing telephone companies; but that was no reason why he should not grant licences to new companies who would probably make use of improved telephone systems much to the public advantage. Notwithstanding the fact that the National Telephone Company's capital had been what was vulgarly termed "watered" to the extent of £2,000,000, the price of their shares was still going up, which showed that the telephone business was a very paying one. He thought that the House was entitled to a clear statement on this subject from Her Majesty's Government as to what policy they intended to adopt with regard to telephones in the future. He should like to suggest that the Postmaster-General should keep the main telephone lines throughout the Kingdom in his own hands, and should allow various companies to supply the local demands. He begged to make the motion which stood upon the paper in his name.

The EARL of JERSEY said that the subject to which the noble duke had called attention was one of considerable interest, because any improvement in the means of our communication was always welcome to the public. It was not necessary that he should follow at any length the remarks of the noble duke, neither did he feel called upon either to defend or to attack the existing companies. He had observed that the noble duke had placed a construction upon the answer of the Postmaster-General in another place which it could hardly be said to bear. The Postmaster-General had said that the Government did not intend to give notice to purchase the undertakings of the telephone companies at the end of the year, but that answer did not debar the Post Office from undertaking telephonic work in cases where it might be thought necessary or desirable. The Government did not intend to adopt the policy of purchase by the State of the telephone companies. To do so would be to involve the State in a gigantic enterprise into which the Government were not prepared to enter. The Government intended to grant licences to new companies which might apply for them; but, of course, each company would have to show that it was able to undertake the work for which it applied. The most important patent rights which gave a sort of monopoly to the present companies would expire in the middle of next year, and then competition would most likely arise, and in that way the public would reap with the least risk the benefits which the noble duke anticipated. He trusted that the noble duke would be satisfied with the statement he had made, and would withdraw his motion.

The DUKE of MARLBOROUGH then asked leave to withdraw his motion.

The motion was by leave withdrawn.

Electrical Lighting Orders.—In the House of Lords on Tuesday last, on the motion of Lord Balfour of Burleigh, the sessional order against a Provisional Order Bill originating in that House being read a first time after May 16th, was dispensed with in respect of a Bill to confirm certain Provisional Orders made by the Board of Trade under the Electric Lighting Acts 1882 and 1883, relating to Aberdeen, Dundee, Kelvinside, and Moss-side and Stretford; and the Bill was brought in and read a first time.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June* 27, 1890.

The New York Municipality and the Electric Light Companies.—The usual row between the City authorities and the electric lighting companies is especially lively at present. Last April, when the bids for street lighting were put in, the electric lighting companies of one accord raised their prices, owing to the immense expense and great inconvenience to which they had been put by the action of the city in the matter of subways. At its last meeting the Gas Commission called for new bids to be open early in July, making the usual threat of going back to gas lighting in case the service should not be furnished on terms more favourable to the city. It is well known to those acquainted with the cost of electric lighting in this city that the increase in price asked for is not without reason, and that the new schedule cannot fairly be considered excessive. It is quite clear that the public will not tolerate the abolition of the electric light, and a return to the dismal apology for lighting furnished in former years by gas.

High Efficiency Transformers.—At the last meeting of the Institute of Electrical Engineers a couple of clever Papers were read bearing upon the efficiency of the alternating-current transformer. The results obtained were very high, 96 per cent. being the efficiency on normal load and 90 per cent. on all-day working. These extremely high figures would almost lead one to suspect some constant experimental error, and it is to be hoped that the investigators will take pains at some future time to check the result by a change in the methods of work.

Gas and Steam-pipe Explosions in New York.—During the past few weeks New York has experienced several severe gas and steam-pipe explosions. The most striking of these I noted in a previous letter; but the subsequent ones have done no small amount of damage to tradespeople and manufacturers. Lower Broadway and adjacent streets are undermined by pipes of every description, where gas mains and steam heating mains vie with each other in doing indiscriminate damage. The reports of the City engineers are specially severe on the New York Steam Heating Company, and unless it amends its ways immediately they recommend that steps should be taken to revoke its charter, on the ground that its business, as now conducted, is a common nuisance. The electrical subways have been special sufferers at the hands of these obstreperous neighbours, and it is exceedingly difficult to maintain insulation on underground wires anywhere within the range of operations of the Heating Company.

Lightning in the Manhattan Company's Station.—A notable exhibition of electrical enterprise occurred the other day, when a severe thunderstorm broke over the city, and the lightning entered the station of the Manhattan Electric Light Company, and left only two or three valuable dynamos out of a total of more than thirty. A very large amount of damage was done; but the work of reconstruction began immediately, and the night after the fire one half the arc lights and 12,000 incandescents were turned on as usual, and by the succeeding night 17,000 incandescents were in regular use. Other electric lighting companies turned in to aid their unfortunate competitor, and the damage was very rapidly repaired.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *July* 8, 1890.

Mention has frequently been made in your columns of the curious system of electrical distribution adopted by the Popp Company; but it is of such a unique character that I think it worth while to again call attention to it. At the present moment the Popp Company have commenced work upon a gigantic system of mains upon the left bank of the Seine. When M. Victor Popp, some little while ago, obtained the 40 years' concession for the distribution of compressed air for the purpose of driving automatic clocks, he succeeded in getting a clause put into his contract to the effect that his compressed-air system could be employed not only for the purpose of working clocks, but in connection with any kind of machinery. It is in virtue of this clause that Mr Popp is to-day laying his vast system of compressed-air mains for driving dynamo machinery.

The station in the Rue de Saint Fargeau has a capacity of 600 horse-power, and produces daily 550,000 cubic metres of compressed air at a pressure of six kilogrammes per centimetre (85·8lb. per square inch). The station now in process of construction on the left bank is situated close to the Orleans railway station. The pipes are being laid in special conduits placed under the pavements. The mains on the left bank will be connected with those on the right at the Bastille and at the Place de la Concorde. An additional station in the Boulevard Richard Lenoir will be connected with the general system. These three stations will supply compressed air to 28 sub-stations, established in various districts of Paris. In the sub-stations the compressed-air motors with steam heaters will drive dynamos which will charge accumulators, and it is only after this long series of transformations that electrical energy will be distributed to the consumers. The works connected with this gigantic, though somewhat irrational scheme, are being pushed forward with great vigour, in the hope that they may be completed by November next.

The provisional station of the Compagnie Continentale Edison, in the Avenue Trudaine, is nearly complete, but the permanent station has made but little progress. The system of underground mains differs somewhat from that laid down along the Grand Boulevard. As previously, bare copper strip is used; but in order to get more conductors into a given space, they are arranged side by side on notched porcelain bridge pieces and also in vertical layers. This arrangement enables a much larger number of feeders to be laid in the small conduit.

At the last meeting of the Société Internationale des Électriciens, M. de Nerville read a Paper on some photometric tests, which he had carried out with M. Lepage and the students of the Laboratoire Centrale. He has ascertained that in the boxes of theatres the mean luminous intensity is 20 bougies, and in ball rooms 30; while at an ordinary writing table 30 bougies are also wanted. On a bright moonlight night the average illumination of the ground is ·33 bougies.

CORRESPONDENCE.

THE MAGNETIC CIRCUIT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read your criticism which you publish in this week's issue. I am not able to understand its meaning. In my article I say nothing about magnetic currents, neither do I hint even that magnetic resistance involves heat waste. For many minutes I have tried to picture in my mind a "magnetic current," and I have failed. The magnetic induction is, however, of the nature of a flux, and has a rate of fall of potential. I do not agree with you that I have chosen the wrong analogy. Oliver Heaviside may have "properly worked out" an electrostatic analogy, but that is no proof there are no other analogies to be found. It is impossible to make any analogy "go on all fours;" and the electrostatic analogy fails at some points as much as any other. For instance, the number of lines of *force* radiated from unit magnetic pole is *independent* of the medium, *i.e.*, the stress is independent; while the stress between two charges is *eminently affected* by the dielectric. Again, in electrostatics, where is the analogue of $B \div H$?

I am familiar with the writings of Oliver Heaviside, and have enjoyed reading them. But I have not yet come across any warrant in them for the statement that there is no analogy between magnetic flux and electric currents. If it is true, and there is no analogy, all my paper is nonsense, and quite unfit for publication; but *if my* EQUATIONS *are correct* (and they are) there *must* be an analogy as far as these equations go.—Yours, &c.,

E. T. CARTER.

School of Electrical Engineering, 12, Prince's Street, Hanover Square, July 5, 1890.

[We comment on this letter in our editorial columns.—ED. *E.*]

PRIMARY BATTERIES FOR LIGHTING PURPOSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent "Electromaniac" gave last week some *primâ facie* reasons in support of his belief that chemical batteries may some day "triumph over steam;" but he omitted

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one very important consideration, viz., that in a primary battery no part of the ingredients used to produce the electric current is lost or "consumed." While producing that current, both zinc and acids undergo changes of composition, the zinc is oxidised and dissolved, the acids are diluted and their acidity weakened; but both retain all that is necessary to allow of their being recovered as valuable commercial products.

If the battery is properly handled, the oxidation of one ton of zinc will produce 1,340 electrical horse-power hours of current, giving in glow lamps the light of 333,000 candles, and in arc lights 1,665,000 candles, which last is 55 times as much light as can be produced from one ton of coal, or 10,000 cubic feet of gas. It can then be wholly recovered as sulphate of zinc crystals by an extremely simple and inexpensive process; and these can again be converted, after oxidation, into metallic zinc, and used over and over again in the battery. The spent acids I convert into dry agricultural fertilisers exceeding in value the richest Peruvian guano.

Your article last week on the gas companies as undertakers of electric lighting (which, however, are in many cases precluded by their statutes from supplying electricity) leads up to the further consideration that the Gaslight and Coke Company provides for an annual dividend of 13 per cent. on the whole of their £5,500,000 of ordinary share capital by means of the sale of their residual products (coke, ammoniacal liquor, and tar), because that circumstance suggests analogous results from the use of chemical batteries to produce electric light, whereas dynamos and steam-engines furnish no residual products applicable to such a purpose.

Again, when recently commenting on the fire which occurred at the house of Mr. R. D. Sassoon, you remarked that the circumstances as described "would point to the presence of a high potential current in the house circuit," and there may probably occur many unlooked-for accidents when London is generally supplied with electricity by currents of the dangerously high potential which the chief companies contemplate employing. But no such risks could possibly occur with primary batteries; for even those which I advocate for the supply of groups of houses and large buildings, lighting, say 1,000 lamps, would only need to be worked with the very low pressure necessary for sending the current over mains two or three hundred feet long, and through the lamps all in parallel.

The internal resistance of the cells, to which "Electromaniac" alludes, becomes almost inappreciable with currents of 1,000 amperes from each cell (multiple cells I mean, such as I use), for with $\frac{1{\cdot}8}{1000}$ we have R = 0·0018. Between the ranges of 19 and 22 cells for lamps of 10 candle-power, such a battery may be worked with a nearly uniform E.M.F. (maintained automatically), even when varying the number of lamps in circuit from 5 up to 1,000.

The cells can be easily filled and emptied from one point of supply much as your correspondent suggests, and I entirely agree with your own observation that any trusting to domestic servants should be rigorously avoided.—Yours, &c.,

O. C. D. Ross, M.Inst.C.E.

15, Relf-road, East Dulwich, July 9, 1890.

[Our correspondent encloses a hypothetical table, showing how six groups of 22 cells may be arranged to supply 1,000 lamps of 10 candle-power, with a nearly uniform pressure of 33 volts.—Ed. *E.*]

ACCUMULATORS WITH POROUS PARTITIONS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of July 4th, under the heading "Accumulators with Porous Partitions," it is stated that M. Chatiliez has written to *L'Electricien* to say that he has met with considerable success by employing ordinary porous partitions between the battery plates. In case your readers should think that this method of applying the ordinary porous partitions is novel, I write to inform you that I have, in connection with the installation at my private residence, for the last eighteen months used these partitions in a similar manner—both plain and perforated—and I consider them in all respects satisfactory. —Yours, &c., Pearson Goward.

BRIGHTON ELECTRIC LIGHTING.

A special meeting of the Brighton Town Council was held yesterday to receive a report from the Lighting Committee, with tenders for the erection of buildings for an electric light generating station, and for supplying and fixing machinery and plant and laying cables for the supply of electricity to a portion of the borough.

The abstract of the Committee's report, which we give below, was published in the leading local paper on Monday last.

The Local Government Board having sanctioned the loans applied for by the Council for the purposes of the electric lighting station and works—namely, £2,500 for the site, repayable within a period of 40 years, and £30,000 for the works, repayable within a period of 25 years—the Lighting Committee beg herewith to submit tenders for carrying out the works. The Committee also report that in consequence of some rights to ancient lights on the east side of the site which have been found to exist, it has been necessary to revise the plans for the generating station, and some other modifications which the Committee deemed advisable have at the same time been adopted. The Committee have invited the contractors who tendered upon the original plans to send in offers for the work as now proposed to be carried out, and the amended plans with the new tenders are submitted herewith. On considering the tenders for the boilers (Section B), the Committee have come to the conclusion that it is advisable to have a third Lancashire boiler in lieu of the Babcock and Wilcox boiler originally provided for. By this alteration the heating power will be slightly increased, and a water-softening apparatus will be unnecessary, which will effect a reduction of £440 in the outlay. It is also thought probable that two sets of storage batteries, instead of four, will be sufficient for present requirements; and it is, therefore, proposed that power shall be reserved to take two sets only, and for the consequent reduction of the contract sum. After setting out the tenders received the report continues:—

The Committee recommend that contracts be entered into as follows; and that, in consequence of the delay since the tenders were received, the time for the completion of the works be extended three months beyond the dates mentioned in the specification, namely:—

For Section A—	
With Mr. John T. Chappell, of 149, Lupus-street, Pimlico, S.W., to erect the buildings for the generating station in accordance with the amended plans	£3,989
For Section B—	
With Messrs. Yates and Thom (W. and J. Yates), of Blackburn, for supplying and setting three Lancashire boilers ...	2,294
For Section C—	
With Messrs. Sharp and Kent, of 34, Victoria-street, S.W., for supplying and fixing four sets of steam dynamos, pumps (piston speed 50ft. per minute), an overhead traveller, and certain instruments, apparatus, and appliances, including six weeks' running of the dynamos. (The dynamos are to be of the Goolden type)	7,027
For Section D—	
With the Electrical Construction Corporation, Limited (formerly known as the E.P.S. Company), Worcester House, Walbrook, E.C., for the supplying and fixing of four sets of storage batteries with stands, switch boards, instruments, and appliances	5,242
[A right to be reserved under the contract for the Corporation to take two sets only of the batteries, the contract price being reduced to £2,700, and the balance of £2,542 being paid if and when the remainder of the batteries are required.]	
For Section E—	
With Messrs. Sharp and Kent, for supplying, fixing, and connecting certain electrical instruments at the Generating Station, North-road	1,140
For Section F—	
With Callender's Bitumen Telegraph and Waterproof Company (Limited), of 101, Leadenhall-street, E.C., for supplying and fixing electrical cables, leads, and wires..... £9,096 For separate test wires, &c..... 204	9,300
For Section G—	
With Callender's Bitumen Telegraph and Waterproof Company (Limited), for supplying and fixing street and other boxes, instruments, and appliances.....	437
Total.....	£29,429
If the Council should decide to take only two sets of storage batteries there will, in respect of the other two sets, be deducted from this total a sum of	2,542
Leaving the net outlay, exclusive of the cost of site, at ...	£26,887

Bromley.—Messrs. Laing, Wharton, and Down have given notice of their intention to apply for a Provisional Order.

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BOOKS, &c., RECEIVED.

"Abstracts of Papers in Foreign Transactions and Periodicals, Excerpt Minutes of Proceedings of the Institution of Civil Engineers." Vol. C., Part II. Edited by James Forrest. (London: Institution of Civil Engineers.)

"Inventions and How to Patent Them." By T. Eustace Smith." (London: Whittaker and Co.)

"The School of Mines' Quarterly." Vol. XI., No. 3. (New York.)

"Facts which prove that Faraday's Two-Force Theory of Electricity is False." Part II. By James Johnstone. (Edinburgh.)

"*Journal* of the Institution of Electrical Engineers." Vol. XIX. No. 87. (London: E. & F. N. Spon.)

"Traité Théorique et Pratique des Machines Dynamo-Électriques." By R. V. Picou. (Paris: Baudry et Cie.)

"Practical Electricity in Medicine and Surgery." By G. A. Liebig, Jr. P.H.D., and George H. Rohé, M.D. (London: F. A. Davis.)

"Electricity in the Diseases of Women." By G. Betton Massey, M.D. (London: F. A. Davis.)

LEGAL INTELLIGENCE.

Bolt v. London Electric Supply Corporation.

In the Westminster County Court on Thursday last week, the case of Bolt v. The London Electric Supply Corporation was before his Honour Judge Bayley.

The action was brought by Messrs. Bolt Brothers and Co., oil merchants, to recover the sum of £42. 12s. 8d. for oils supplied by them to the defendant firm. The oil supplied was of a peculiar character, and was used for the engines driving the electric light machinery at the Grosvenor Gallery. There were now 110 gallons owing for, and they formed the subject of the present claim.

Mr. CLEATON, a member of the plaintiff firm, said that in March last year he had an interview with some of the heads of the defendant firm with reference to making some lubricating experiments on the defendants' engines at the Grosvenor Gallery station. Certain oil was specially prepared for the work, and on March 8th the experiments took place. They did not, however, prove satisfactory, but that was purely owing to the defendants not fitting up a proper oil tank. A number of drums of oil were supplied, containing in all 100 gallons. A portion of the oil had been used, but no part had ever been returned by the defendants.

For the defence, Mr. LYNCH submitted that, according to an agreement entered into between the parties, either side were to terminate the experiments if they were found to be unsatisfactory. Had they gone on for a month as arranged, no doubt the defendant company would have had to pay the plaintiff the agreed sum of £50. The trials, however, were concluded upon the very same day they were commenced; therefore it was contended that the defendants had incurred no liability as the matter had fallen through, but a sum of £2. 9s. 6d. had been paid into Court for the one day's experiment.

His HONOUR said he failed to see how the plaintiff could show that oil supplied, as in the present case, was oil sold and delivered. It was simply an experiment. Judgment would be entered for the defendants, with costs.

TRADE NOTES AND NOTICES.

TENDERS WANTED.—The Goole Local Board invite tenders for lighting the town with gas or otherwise for twelve months from September 1st next. Full particulars may be obtained from Mr. George England, Clerk to the Local Board, to whom tenders must be sent by the 24th inst.

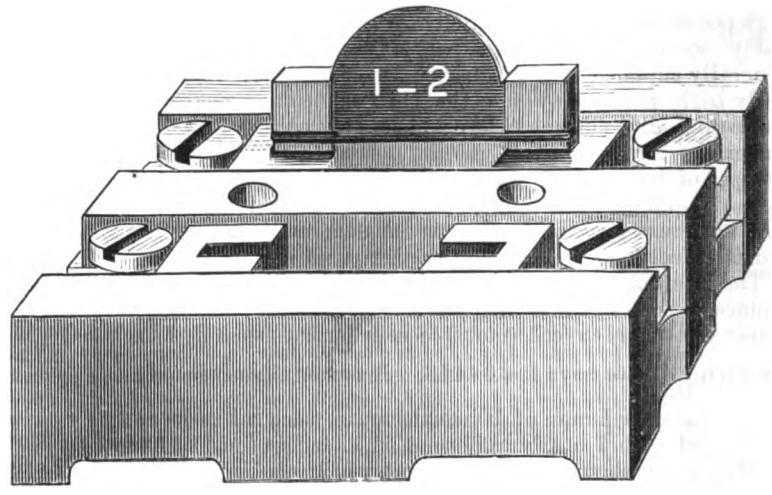
DISSOLUTION OF PARTNERSHIP.—It is announced that the partnership between Messrs. H. F. Price and H. Thompson, trading as the Eclipse Electrical Case and General Cabinet Works at Phœnix-place, Gray's-inn-road, and St. Peter's-street, Islington, has been dissolved.

MESSRS. CATHCART AND PETO.—We are informed that this firm has acquired the business and factory of the Vulcan Manufacturing Company, Rocliffe-street, Islington, London, N. The title of the latter firm will be retained, and Messrs. Cathcart and Peto will continue the business as their Electric Bell department, in addition to their Hatton Garden Works.

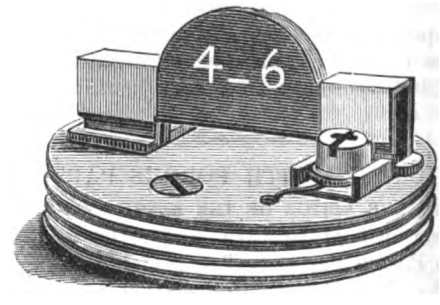
EDWIN FOX AND CO. (IN LIQUIDATION).—We have received from the liquidator the debtor and creditor cash statement respecting the affairs of this firm, which went into liquidation at the end of 1887. The accounts are made up to February 18th, 1890, and were received by us on July 10th. Some £25,000 appear to have been collected, with an exactly equal amount expended, which is a very satisfactory realisation for the creditors, the more particularly as it has only cost £1,211 3s. 8d. to realise, of which sum the liquidator is content with £549 16s. 2d., which from the accounts rendered seems to be about £300 less than might legally have been claimed by him! We were given to understand at the early part of 1888 that the creditors of the Company would receive a considerable dividend out of the estate; but this, we regret to say, is not to be. The liquidator is Mr. John S. Ball, 1, Gresham-buildings, Basinghall-street, London, E.C.

MESSRS. CROGGON AND CO. (LIMITED).—It will be remembered that Messrs. Croggon and Co., in November last, added to their electrical department Messrs. Pressland and Co.'s stock and plant, appointing Mr. W. T. Pressland manager of this department. We have received an illustrated catalogue from the firm, showing a number of artistic electric light fittings, an electric show-board, various qualities of electric bells, electric bell circuit connections, indicators, indicator movements, brass and bronze pulls and pushes, china pushes, wood pushes, switches, galvanometers, contacts, fire alarms, batteries, porous pots, battery jars, tubes, battery boxes, gongs, medical coils, magneto machines, induction coils, terminals, telephone sets, sections of lightning conductors, insulators, galvanised brackets, &c. The catalogue also contains illustrations of speaking tube fittings, and tables and price lists of the firm's high-conductivity electric wires for bell work, telephones, &c.

THE "VERITY PATENT SAFETY CUT-OUT."—In this cut-out (an illustration of which appears below) contacts are placed at a given distance apart for a given quantity of current. The mounted fuse is also of a given length to exactly fit the contacts of the fuse blocks, making it impossible to fix a large fuse into a block where the length between the contacts is intended for a smaller size. A



small fuse can be put into a large block if required, but on being overloaded would at once melt, and, as each block is stamped with a number of amperes, the contact pieces are arranged for; when once the proper size of cut-out is fixed, a fuse of a larger size can by no inadvertency be inserted. The safety blocks are made interchangeable as far as possible, so that the same fixing screws and



holes will do for any size block. This is found convenient, as alterations are often made in house-wiring, and lights added on to branch circuits where the carrying capacity of the branch conductors admits. Mr. J. G. S. Cunnington, the inventor of the cut-out, has made a series of careful tests on fuses, and has found that if a lead or composition fuse be not coated with grease, resin, or a similar compound, it becomes oxidised when heated, going to a white heat, and carrying 50 per cent. more than the current required to melt it when not so coated. As an additional security,

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therefore, all the fuses supplied with these blocks are treated with a compound of resin, which insures the fuse melting at its normal melting point—612°F. The parts are very well made, and have sufficient metal to insure contact and to avoid the joints heating, while the screw connections are of ample size for the cables.

MESSRS. F. H. ROYCE AND CO.—We have received from Messrs. Royce and Co. their new price list of compound or shunt-wound dynamos, for which the firm claim an exceedingly high efficiency.

POSTAL REFORM.—We regret to say that the announcement in our last issue, that the Postmaster-General had agreed to an alteration in the Book Post Rules, by which open envelopes could be used, was incorrect.

COMPANIES' MEETINGS & REPORTS.

The India Rubber, Gutta Percha, and Telegraph Works Co., Limited.

The half-yearly general meeting of this Company was held yesterday at the Cannon-street Hotel; Mr. S. W. SILVER presiding.

The SECRETARY (Mr. Tyler) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, the object of our meeting is set in the notice just read; and in accordance therewith I move,

"*That an interim dividend of 5 per cent., or 10s. per share, free of income-tax, payable on and after the 11th inst., be now declared.*"

In doing this I may remark that a rough estimate formed of the amount of sales in the past six months will fully justify it, as it is in excess of that of any previous half-year, notwithstanding the severe competition met with and the considerable increase in the price of the raw material. I am glad to be able to inform you that the works are fairly well employed. Under these circumstances we look forward to the pleasure of meeting you at the commencement of another year, when the books of the Company will be made up. I need scarcely remind you that these results have been attained only by the closest attention to the business, together with the co-operation of all employed in making this institution a great success.

The MANAGING DIRECTOR (Mr. Gray) I have much pleasure in seconding the resolution. You are aware that our workpeople at Silvertown were out on strike from the 18th September to the 10th December last year. This did not occasion us much loss, as we could execute our orders from our works in France. The strikers were aided by some lawless ruffians in intimidating and using violence to our respectable workpeople who wished to continue their work. If the police authorities had taken proper measures to prevent this, the extension of the strike would have been prevented and the places of the small number who went out on strike at the beginning would have been filled up by the new men, and the strike would have ended in a week. As it was, the strike continued about 12 weeks, and the loss to the workpeople was about £20,000, which they would have received had they been allowed to remain at work.

The resolution was carried unanimously.

On the motion of Dr. SMALL, seconded by Mr. RUDD, a vote of thanks was passed to the Chairman and Directors; and the proceedings terminated.

Eastern Telegraph Company (Limited).

The following is the report and accounts of the Directors for the half-year ended March 31st, 1890, to be presented to the thirty-sixth half-yearly ordinary general meeting, to be held at Winchester House, E.C., on Thursday, the 17th inst., at one o'clock:—

The revenue for the period amounted to £424,023. 14s. 3d., from which are deducted £98,477. 16s. 3d. for the ordinary expenses and £47,520. 2s. 11d. for expenditure relating to repairs, renewals of cables, &c., during the half-year. After providing £2,943. 10s. 7d. for income-tax, there remains a balance of £275,082. 4s. 6d., to which is added £61,151. 1s. 5d. brought from the preceding half-year, making a total available balance of £336.233. 5s. 11d.

From this amount there have been paid—

Interest on Debentures and Debenture Stock	£28,274	13	1
Dividend on Preference Shares	20,474	3	3
An interim dividend of 1½ per cent. on the ordinary shares	50,000	0	0
	£98,748	16	4

Leaving a balance of £237,484. 9s. 7d., from which £125,000 has been carried to general reserve.

The Directors now recommend the declaration of a final dividend for the year ended March 31, 1890, of 2s. 6d. per share and a bonus of 3s. per share, amounting together to £110,000, both payable on the 18th inst., free of income-tax, and making, with the three previous payments on account, a total distribution of 13s. per share, or 6½ per cent., for the year on the ordinary shares. The balance of £2,484. 9s. 7d. shown at the foot of the revenue account is proposed to be carried forward to the next half-year.

The revenue includes £74,337. 8s. dividend and bonus for the half-year upon the Company's investments in the Eastern and South African, the Black Sea, the Direct Spanish, and the African Direct Telegraph Companies.

The Convention referred to at the last general meeting between the French Government and this Company, for the renewal of the agreement for the direct line through France, and the landing and working of submarine cables at the Company's station at Marseilles, has since been ratified, and the agreement has been renewed between H.M. Postmaster-General for a special wire by land line and cable connecting this line with London.

A Convention has been entered into with the Italian Government for the prolongation for 20 years of the existing concessions, for the working and maintenance of submarine telegraph cables between Italy, Malta, Corfu, and Egypt.

The Directors have concluded an agreement with the Turkish Government for the laying of a short section of cable between the Island of Perim and Sheikh Seyd, which will bring to this Company's system the traffic from Hodeida, Mocha and other points on the coast of Arabia now being connected by the Turkish Government with their system of land lines to Jeddah.

The International Telegraph Conference has been held in Paris, at which the Chairman, Managing Director, and other representatives of the Company attended. The interests of the Company were carefully watched, and the result has been on the whole not unsatisfactory.

Sundry reductions in the Continental tariffs were made, to come into operation in July, 1891, which will affect the Company's revenue to a moderate extent, but the Directors hope that the increase of traffic will eventually recoup the loss.

Negotiations of an important character are being carried on between the Eastern Extension Company and the Australian Colonies, with a view to effecting a large reduction in the tariff to Australia. This Company is interested in these negotiations in so far as it will take a part of the risk, trusting that the reduction of tariff will tend to a large increase of traffic, and it is believed that these negotiations will speedily be brought to a satisfactory conclusion.

The several sections of the Company's cables are in good working order, with the exception of the original Red Sea cable, which connects Suakim with Suez and the Island of Perim. The frequent interruptions of this cable taken in connection with the prospect of increased traffic to Australia necessitates the laying of an additional cable in the Red Sea from Suez to Aden which the Directors expect to have completed and in working order before the end of this year. The cost of this will be taken mainly from the reserve fund.

The South of England Telephone Company (Limited).

The following is the report of the Directors to be presented to the seventh ordinary general meeting of the shareholders, to be held at Winchester House, E.C., on Friday, the 18th inst., at 12 o'clock:—

The expenditure on capital account for the past year amounts to £14,116. 2s. 10d., bringing the total of that account to £78,418. 2s. The revenue account shows a sum of £21,549. 18s. 9d. for subscriptions and rentals, and a net credit balance of £6,148. 5s. 4d.; making, with the sum of £627. 1s. 2d. brought forward from last year, an available balance of £6,775. 6s. 6d. Of this amount, the sum of £1,796. 14s. 7d. has been absorbed by the payment of an interim dividend on the Preference shares at the rate of 6 per cent. per annum for the half-year ending October 30, 1889. In order to strengthen the position of the Company, the Directors have considered it advisable to carry £1,000 to the reserve fund; and they now recommend the payment of a final dividend at the rate of 6 per cent. on the Preference shares (£2,096. 6s. 2d.) for the half-year ending April 30, 1890, and the payment of a dividend of ½ per cent. on the Ordinary shares, free of income-tax (£1,500) for the year, leaving a balance of £382. 5s. 9d. to be carried forward.

The completed trunk lines are as follows:—Brighton—Shoreham; Brighton—Eastbourne; Brighton—Worthing; Shoreham—Worthing; Brighton—Hurst; Brighton—Newhaven; Brighton—Rottingdean; Brighton—Lewes; Lewes—Eastbourne; Canterbury—Ramsgate; Ramsgate—Margate; Ramsgate—Sandwich; Ramsgate—Deal; Canterbury—Faversham; Canterbury—Whitstable; Canterbury—Dover; Dover—Folkestone; Chatham—Maidstone; Norwich—Great Yarmouth; Northampton—Wellingboro'; Wellingboro'—Kettering; Kettering—Rushden; Tunbridge Wells—Tonbridge.

The trunk lines in process of construction are:—Canterbury—Ashford; Faversham—Sittingbourne.

At the 30th April this year 2,265 exchange lines and 583 private lines were completed, and 91 exchange lines and 19 private lines were in course of construction.

Telephone exchanges are now open at the following places:—

Brighton	Hastings and St. Leonards	Margate	Rushden
Cambridge		Newhaven	Sandgate
Canterbury	Hurst	Northampton	Sandwich
Chatham	Hythe	Norwich	Shoreham
Deal	Ipswich	Oxford	Tunbridge Wells
Dover	Kettering	Peterborough	Watford
Eastbourne	King's Lynn	Ramsgate	Wellingborough
Faversham	Lewes	Reading	Whitstable
Folkestone	Maidstone	Rottingdean	Worthing
Great Yarmouth			

Mr. D. Owen Bateson retires from the Board by rotation, and being eligible offers himself for re-election. The shareholders' auditor, Mr. J. Weise, retires, and is eligible for re-election.

The following comparative statement of exchange and private line business of the Company is issued with the report:—

	Exchange.	Private.
April 30th, 1886	687	248
April 30th, 1887	1,130	348
April 30th, 1888	1,521	386
April 30th, 1889	1,972	500
April 30th, 1890	2,356	602

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NEW COMPANIES REGISTERED.

BARRY AND CARDIFF ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object, to carry on the business of electrical engineers.

BRISTOL ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

CAMBERWELL AND ISLINGTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object, to carry on the business of electrical engineers.

CANTERBURY ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on business as electrical engineers, &c.

CARDIFF ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

DEVONSHIRE ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object, to carry on the business of electrical engineers.

DISTRICT MESSENGER SERVICE AND NEWS COMPANY (LIMITED).—Registered by Ashurst, Morris, Crisp and Co., 6, Old Jewry, London, E.C., with a capital of £200,000, in £5 shares, of which 200 are founders' shares. Objects: To manufacture, fit up, let, or sell electrical appliances of all kinds for the transmission, communication, or making in any way of messages and signals, or to serve as alarms, watch signals or indicators, and to engage and procure messengers and watchers, adopting therefor an agreement made with Charles Tweed Russell, of 18, Southwell-gardens, South Kensington, the particulars of which are not specified in the Articles of Association.

EAST COAST ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object, to carry on the business of electrical engineers.

S. Z. DE FERRANTI (LIMITED).—Objects: To carry on the business of electrical engineers and contractors for the supply of electric power. Capital, £100,000, in £10 shares. Subscribers of one share each are: S. Z. de Ferranti, engineer, Charterhouse-square, London; Francis Ince, solicitor, St. Benet-chambers, Fenchurch-street; C. P. Sparks, engineer, Charterhouse-square; Fred. W. Hunter, accountant, 2, Dunwood-road, Stroud Green; Arthur Wright, electrician, Preston Park, Brighton; H. W. Kolle, engineer, Egremont, Tulse Hill; and Edward B. Ince, solicitor, St. Benet-chambers, Fenchurch-street. Vote per share. First Directors (two to five), S. Z. de Ferranti, Francis Ince, and Charles Pratt Sparks, and their appointees. Qualification, 100 shares. Remuneration to be fixed by the Board with consent of general meeting. Borrowing limit not specified. Registered, June 26th, by Gerard B. Ince, solicitor, St. Benet-chambers, Fenchurch-street, London.

HANLEY (STAFFORDSHIRE) ELECTRICITY SUPPLY COMPANY.—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

INDIA RUBBER ESTATES COMPANY (LIMITED).—This Company was registered on the 2nd inst., with a capital of £235,000 in £1 shares, to cultivate the india-rubber and other gum-producing trees and plants, and to utilise the produce thereof. The Company will enter into an agreement with Mr. Otto Hienemann. The number of Directors is not to be less than 3, nor more than 9; qualification, £250 in shares. The subscribers are to appoint the first. Remuneration, £2,000 per annum, divisible. and in addition £100 to each Director for every £5 per cent. per annum dividend beyond £15 per cent. Solicitors, Messrs. Gordon, Ross and Douglas Norman, 8, Draper's-gardens.

IPSWICH ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

JOSEPH KAYE AND SONS (LIMITED).—Registered with a capital of £30,000 in £5 shares, to acquire the business of Joseph Kaye and Sons (Limited), Leeds, wholesale dealers in ironwork.

KIDDERMINSTER ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object, to carry on the business of electrical engineers.

LOUGHBORO' ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

MANCHESTER ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C. with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

NEW CADOGAN AND BELGRAVE ELECTRIC SUPPLY COMPANY (LIMITED).—Registered by Brook, Freeman and Batley, 89, Chancery-lane, W.C., with a capital of £1,000 in £10 shares. Objects, to take over as a going concern the business of the Cadogan Electric Light Company (Limited), which was incorporated March 21, 1887, with a capital of £30,000 in £5 shares, and returned December 31, 1889, as the number of shares taken up 1,194 Preference and 765 ordinary shares, upon each of which £5 had been called up, the total sum of £9,772. 10s. having been received in respect of same, and £22. 10s. remaining unpaid. The new Company also propose to carry on the general business of electricians, mechanical engineers, and manufacturers, workers, and dealers in electricity, motive power, and light. Subscribers of one share each are: Arthur Greenwood, mechanical engineer, 8, Cavendish-road, Leeds; A. W. Thynne, lieut.-colonel, 50, Cadogan-square, London, members of the old Company; George Chapham, secretary thereof, 48, Linver-street, Fulham; and four others.

NORTHERN COUNTIES ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Nicholson and Jennings, 13, Victoria-street, London, S.W., with a capital of £1,000 in £1 shares, of which 100 are founders' shares. Objects: To carry on in the county of Northumberland and elsewhere the trade or business of electric lighting, and supply by means of electricity illuminating, heating, and motive power or force for telegraphic or other means of communication. Subscribers of one founders' share each are: Ralph Thicknesse, solicitor, 11, Abchurch-lane; Edward J. Jennings, engineer, 13, Victoria-street; F. B. Nicholson, engineer, 9, St. Petersburgh-place, Bayswater, all of London, and four others.

PADDINGTON AND BAYSWATER ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Nicholson and Jennings, 13, Victoria-street, London, S.W., with a capital of £1,000, in £1 shares, of which 100 are founders' shares. Objects: To carry on in Paddington and Bayswater the trade or business of electric lighting, and supply by means of electricity illuminating. heating, and motive-power or force for telegraphic or other means of communication.

PASCOE, GRENFELL, AND SONS (LIMITED).—Registered by Godden, Holme, and Co., 34, Old Jewry, London, E.C., with a capital of £200,000. in 10,000 Preference shares of £10 each, fully paid up, with fixed cumulative dividend at the rate of 4 per cent., and 10,000 ordinary shares of £10 each. Objects, to carry on the business of smelters, merchants, and dealers in copper, and of colliery owners and of any other business of the firm of Pascoe, Grenfell, and Sons.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
PHOSPHOR BRONZE
VULCAN
DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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PENZANCE ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

PROVINCIAL ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object, to carry on the business of electrical engineers.

STAMFORD-HILL, TOTTENHAM AND EDMONTON ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).—Registered by Fox and Thicknesse, 11, Abchurch-lane, E.C., with a capital of £1,000 in £1 shares. Object, to carry on the business of electrical engineers.

WESTON-SUPER-MARE ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

WEYMOUTH ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by S. Morse, 4, Fenchurch-avenue, E.C., with a capital of £100 in £1 shares. Object, to carry on the business of electrical engineers.

WOOLWICH DISTRICT ELECTRIC LIGHT COMPANY (LIMITED).—Registered by George Whale, 54, Cannon-street, E.C., with a capital of £10,000 in £1 shares. Object, to carry on the business of an electric light company.

CITY NOTES, &c.

ALLGEMEINE ELECTRICITATS GESELLSCHAFT, BERLIN.—This Company is about to increase its capital by 3,000,000 marks. The new shares will be offered at 55 per cent. premium.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended July 4th amounted to £4,481, as compared with £4,068 for the corresponding period last year.

DIRECT SPANISH TELEGRAPH COMPANY.—The receipts of this Company for the month of June show an increase of £485 as compared with the corresponding period.

EASTERN TELEGRAPH COMPANY.—Notice is given that the register of transfers of this Company will be closed from the 10th to the 17th July, both days inclusive.—The traffic receipts of this Company for the month of June amounted to £51,019, as against £44,805 for the corresponding period of 1889, or an increase of £6,214.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic returns of this Company for the month of June are £43,198, as against £39,350 for the same period last year.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in June, 1890, £24,600; January 1 to June 30, 1890, £130,400. Corresponding months in 1889, £129,400; ditto in 1888. £132,000.

INDIA RUBBER ESTATES COMPANY (LIMITED).—This is the title of a new Company issued this week with a capital of £225,000 in £1 shares, the list of subscribers for which closed yesterday. The Company is formed to work a concession from the Government of Siberia for collecting and exporting india-rubber and gutta-percha for the European and American market, and for the purpose of acquiring and working other concessions relating to india-rubber and gutta-percha from other foreign Governments in Africa, America, Madagascar, &c.

MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The offices of this Company have been removed from 2, Tokenhouse-buildings, to Langthorne House, Copthall-avenue, London, E.C.

STOCK EXCHANGE.—The Committee have appointed to-day (Friday) the settling day in the Morgan Crucible Company (Limited), Preference Shares, Nos. 1, to 20,000; and have ordered these securities and the Commercial Cable Company's $7,216,000 capital stock to be quoted in the official list.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED). Notice is given that the transfer books of this Company will be closed from the 7th to the 15th inst., both days inclusive, preparatory to the payment of an *ad interim* dividend of 12s. per share to all shareholders on the register on the 7th inst.

WEST END STREET RAILWAY COMPANY OF BOSTON.—This Company, now working a large percentage of its entire equipment by electricity, has declared a semi-annual dividend of 4 per cent. on the Preferred, and of 5 per cent. on the common stock of record June 14th, payable July 1st.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the week ended July 4, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,451.

COMMERCIAL AND INDUSTRIAL FINANCE.—On Wednesday, July 2nd, the *Financial News* dealt with the subject of the profits of joint-stock companies, showing in a carefully-compiled table the appreciation in the value of shares in a number of commercial and industrial concerns, including many electrical companies. On Monday last our contemporary returned to the subject, and showed in another interesting table the dividends paid by the various companies since their formation into limited liability companies. So much has been written on the seamy side of the question that we think it only right to show that so far as electrical companies are concerned there are two sides to the matter; and the following extracts from these tables will no doubt be interesting to our readers. It will be seen that the total dividends paid amounts to no less than £16,075,420, while the appreciation in value of the shares is £26,813,718. Our contemporary promises some further figures later on, which, we have no doubt, will be of equal interest with those previously given:—

Name of Company.	Date established.	Capital.	Amount returned in divs.	Percentage to present capital.	Present market value.
		£	£	£	£
Bell's Asbestos Ord.....	1888	100,000	45,000	45	310,000
Do. 5% Debs	1888	61,100	6,110	10	61,711
Brazilian Submarine Ord.	1873	1,300,000	1,028,000	94½	1,543,750
Do. 5% Bonds	1884	84,500	41,120	25	86,190
Do. 5% 2nd Series..	1886	75,000	11,250	15	78,750
Crompton and Co. Pref..	1888	100,000	5,000	5	110,000
Cuba Submarine Ord.....	1870	160,000	193,600	121	196,000
Do. 10% Pref.....	1870	60,000	120,000	200	165,000
Direct Spanish 10% Pref.	1872	30,000	51,000	170	57,000
Eastern Ordinary	1872	4,000,000	3,860,000	96½	5,700,000
Do. 6% Pref.....	1872	700,000	756,000	108	1,085,000
Do. 5% Debs	1879	200,000	110,000	55	219,000
Do. 4½% Mort. Debs.	1882	1,200,000	384,000	32	1,290,000
Eastern Extension Ord...	1873	2,500,000	2,375,000	95	3,625,000
Do. 6% Debs.....	1873	320,000	307,200	96	326,400
Elmore's Patent Copper.	1889	93,400	46,700	50	256,850
G. North. of Copenhagen	1872	1,500,000	1,800,000	120	2,400,000
Do. 5% Debs. (1881)	1881	15,000	6,750	45	15,525
Do. 5% Debs. (1883)	1883	230,000	80,500	35	244,650
Greenwood & Batley Ord.	1888	93,340	18,670	20	116,675
Do. 7% Cum. Pref.	1888	58,340	7,470	14	64,008
Indiarubber, G.P., &c. .	1864	416,000	1,050,400	252½	811,200
Do. 4½% Debs.	1886	200,000	36,000	18	208,000
Indo-European	1868	425,000	524,870	123½	646,000
L. Platino-Braz. 6% Debs.	1878	100,000	66,000	66	108,500
Manganese Bronze, &c...	1882	71,700	32,800	45¾	107,550
National Telephone	1881	1,984,375	221,000	10	3,046,640
Do. New	1889	249,125			255,353
Do. 6% 1st Pref.....	1881	150,000	72,000	48	191,250
Do. 6% 2nd Pref....	1881	120,000	57,600	48	157,500
Ruston, Proctor & Co Deb.	1889	200,000	10,000	5	206,000
Submarine Cables Trust.	1871	338,100	365,140	108	385,434
Swan United Elec. Light	1882	276,321	16,570	6	414,482
Teleg. Cons. & Main. Ord.	1864	448,200	1,949,679	435	1,680,750
W. Coast of Amer. 8% Deb.	1877	150,000	150,000	100	165,000
West. & Braz. 'A' 6% Deb.	1880	200,000	120,000	60	215,000
Do. 'B' 6% Debs...	1880	250,000	150,000	60	263,750
		18,404,501	16,075,420		26,813,718

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 2.		Price Wednesday, July 9.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 9.	
£								£ s. d.		Highest.	Lowest
			TELEGRAPHS.								
1,381,380	Stock	12/6	Anglo-American	50	51	50	51	5 17 10	Jan., Apr., July, Oct	51	..
2,809,310	Stock	25/0	Do. Preferred	86	87	85½	86½	5 14 6	,, ,,	87	85
2,809,310	Stock	..	Do. Deferred	14½	15	14	14½	..	.. ..	14½	14½
250,000	£100	4%	African Direct, 4 per Cent. Debentures ....xd	97	100	97	100	4 0 0	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine ....xd	11⅜	12	11⅛	12⅛	6 2 9	Mar., June, Oct., Dec.	11⅛	11⅛
69,200	100	5%	Do. 5 per Cent. Bonds	101	103	102	104	4 17 0	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series) ....xd	103	107	103	107	4 7 10	June and December	103½	..
..	$100	..	Commercial Cables	104½	104⅝	103	105	..	.. ..	..	..
16,000	£10	9/0	Cuba Submarine	12	12½	12½	12⅝	7 4 0	February and August	12⅝	12½
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	,, ,,	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3	4	3½	3⅝	5 3 6	March & September	3⅝	3½
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October..	..	..
60,710	20	3/6	Direct United States	10⅛	10⅝	10⅛	10⅝	6 14 11	Jan., Apr., July, Oct.	10 5/16	10⅛
400,000	10	2/6	Eastern	14	14½	13⅞	14½	4 11 6	,, ,,	14½	14
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	,, ,,	15½	15 5/16
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	107⅛	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	14½	14⅝	14½	14⅝	4 16 7	Jan., Apr., July, Oct.	14⅝	14½
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101	103	101	103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900 ..xd	103	106	103	106	4 7 4	January and July ..	106	105
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900 xd	100	103	100	103	4 12 3	,, ,,	..	..
180,227	10	2/0	Globe Telegraph and Trust	9	9½	9	9½	5 9 7	Jan., Apr., July, Oct.	9½	9
180,042	10	6%	Do. 6 per Cent. Preference	15	15½	15½	15⅝	3 18 6	,, ,,	15⅝	15
150,000	10	5/0	Great Northern ....xd	15⅝	16⅛	15⅝	16⅛	4 12 4	Jan., July, and April	16	15⅞
15,000	100	5%	Do. 5 per Cent. Debentures, 1881 ....xd	100	103	100	103	4 17 1	January and July ..	101	100½
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	105	108	4 13 3	March & September	..	..
17,000	25	37/6	Indo-European	37	39	37	39	6 8 2	April and October ..	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞	8⅛	7⅞	8⅛	6 1 3	April and October..	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	112	116	112	116	..	.. ..	..	..
15,609	£10	5%	West African	9½	10⅛	9⅝	10⅛	4 10 11	,, ,,	10	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	99	102	4 18 0	March & September	101	99½
30,000	10	2/0	West Coast of America	6	6½	6	6½	8 11 5	January and July ..	6	..
150,000	100	8%	Do. Debentures 8% ....xd	108	112	108	112	5 11 0	June and December	110	109
88,321	10	Nil.	West India and Panama	2⅜	2⅝	2⅜	2⅝	..	.. ..	2⅜	2⅜
34,563	10	6/0	Do. 1st Preference 6%	11	11½	11	11½	5 4 4	April and October..	11½	..
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12½	13½	12½	13½	..	.. ..	12⅝	..
64,572	15	6/0	Western and Brazilian	10	10⅛	9⅞	10⅛	..	May and November	10⅛	10
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6⅞	7	..	..	6⅞	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3½	4	3⅝	4	..	..	4	3⅞
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,350	14/0	0/5⅝	Consolidated Telephone Const. and Maintenance..	⅛	⅜	⅛	⅜	..	Yearly	⅜	..
220,000	£1	3%	Oriental (11s. paid)	½	⅝	½	⅝	4 8 3	Yearly	..	..
386,375	5	3/0	National	5⅛	5⅜	5⅛	5⅜	..	June and December	5⅜	5⅛
49,525	5	1/4½	Do. New	5⅛	5⅜	5⅛	5⅜	..	..	5⅜	..
15,000	20	..	Do. 6 per Cent. Cumulative 1st Preference..	12½	13	12½	13	4 12 4	June and December	13	12⅞
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Preference..	10½	10¾	10½	10¾	..	,, ,,	10⅝	10½
209,750	1	..	South of England, Ordinary	⅛	⅜	⅛	⅜	..	..	¼	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	2⅜	3½	2⅜	3½	..	.. ..	..	..
55,000	5	2/0	United River Plate	4⅜	5	4⅜	5	..	January and July ..	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock ..... xd	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures ....xd	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅛	2⅜	2⅛	2⅛	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4⅜	5½	4⅛	5	..	..	5⅛	5
42,853	5	..	Westminster Electric Supply	1⅜	2	1⅜	2	..	..	1⅜	1⅛
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	2⅛	2⅜	1⅞	2⅛	..	..	2⅛	..
63,416	2	1/2	Do. Preference	1⅝	2	1⅝	1⅞	..	..	1⅞	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5½	5⅝	5½	5⅝	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..		..		..	..	..	..
409,000	10	..	Electric Construction	9¾	10¼	9¾	10¼	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5½	6	5⅝	6	..	..	5 1/16	5 1/16
20,000	5	..	Fowler-Waring Cables	2	2⅛	2	2⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works..	19	20	19	20	5 0 0	February & August	19⅞	19⅛
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	103	105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5⅛	5⅜	5⅛	5⅜	3 13 0	..	5 5/16	5 1/16
37,350	12	36/0	Telegraph Construction and Maintenance	44	46	44	46	5 3 11	March and July.....	45⅛	44
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894 ....xd	100	102	100	102	4 8 8	..	..	..

JABLOCHKOFF'S **DISTRIBUTION PATENT**

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

The first Paper read at the Edinburgh meeting of the Institution of Electrical Engineers on Tuesday last was essentially of a practical character, inasmuch as it enabled the members to make the best possible use of the short time at their disposal by directing their attention to that which was really deserving of notice. In reading his Paper "On Some of the Chief Features of the Exhibition, and mainly of the Electrical Section," the author, Dr. Walmsley, acted the part of scientific showman; and if the office which he thus performed was not characterised by that originality which scientific authors are usually supposed to aim at, it was at least very useful. It is strange that papers of this kind are not more often forthcoming. Last year, when the Institution met at Paris, some members suggested that a French scientist should be asked to read a Paper descriptive of the more important electrical exhibits, but the Council did not think it expedient to accede to this proposal, being apprehensive that the advertising element might be uppermost in such a Paper, and interfere with the scientific dignity and impartiality of the Institute. The consequence was that we had no such Paper, and members had to find out the best way they could what was, and what was not worth inspecting. This, of course, means considerable waste of time and vital energy. To look through exhibitions entails physical and mental exertion, and the more we can reduce the exertion the greater will be the ultimate gain to be derived from the inspection of really important objects.

As a practical guide to the Exhibition, Dr. Walmsley's Paper was all that could be desired. It dealt first with the exhibits of historical interest, and then went on to describe those representing machinery and apparatus in use at the present time. Telegraph-engineers will be interested to learn that amongst the historical exhibits shown by the Post Office is one which identifies Charles Morrison with the first electric telegraph. The first proposal for such a telegraph was published in the *Scots Magazine* of 1st February, 1753, over the initials "C. M.," and according to this proposal the telegraph would consist of 24 insulated wires erected between the points to be put in communication, one wire for each letter of the alphabet, and words would be spelled out by electrifying the wires from one end in succession. At the other end of the line particles of paper or straw would be attracted also in succession, and thus messages received. Whether a telegraph has ever been constructed on this principle seems doubtful, and it is equally doubtful whether, even if Morrison's idea had been brought into practical form, we should call him the father of the electric telegraph. It is one thing to vaguely indicate certain scientific possibilities, and quite another thing to carry out practically a new idea. This Morrison certainly never did.

Whilst describing Sir William Thomson's syphon recorder, Dr. Walmsley made incidentally a remark which will be endorsed by all English electricians. He drew attention to the fact that the D'Arsonval galvanometer, about which we have heard so much during the last few years, is nothing else but a revival of the corresponding part in the syphon recorder, and that it therefore should properly be called the Thomson galvanometer. The wonder is that the similarity between the two instruments has not been pointed out before. The arrangement of a coil suspended between fixed poles and an inner soft-iron fixed armature is, as Dr. Walmsley points out, to be found in Maxwell.

The information given as regards the extent to which the Delany Multiple Telegraph is in use in this country had to be corrected by Mr. Preece. Instead of there being only two lines worked by this system, it turned out that there are some 15 or 16. This is a fair list of applications for an instrument which was rather neglected in the country of its birth, and only brought to light by the official recognition it received from our own telegraphic authorities, who, in this case, were certainly not behind-hand in recognising the value of an invention made "outside of the department."

On the subject of dynamo-electric machines Dr. Walmsley had a good deal of interesting information to lay before the meeting. Of historic interest is the first magneto-electric machine built in 1844. This machine was also shown last year at Birmingham, and was pretty fully described in these columns in our issue of October 4, 1889. The armature has eight coils, and the field is composed of four permanent horseshoe magnets, each provided with a keeper of soft iron, which can be fixed at any point along the limbs, thereby more or less short-circuiting the flux of magnetic lines. This provision was adopted to regulate the electromotive force, so as to suit any kind of depositing work for which the machine might be required. Of modern machines, those designed for

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ship lighting are naturally well represented in an exhibition held in a district so important for marine work generally. On board ship compactness of plant is one of the primary considerations, and in this connection it is interesting to compare the different exhibits as regards the relation between floor space occupied by the combined engine and dynamo, and the output of the latter. This has been done by Dr. WALMSLEY, and we give below his table in an abbreviated form.

Exhibitors.	Output in kilowatts.	Revolutions per min.	Steam pressure lbs. per sq. in.	Floor space occupied.	Watts per sq. ft. of floor space.
King, Brown	44	300	120	8′ 6″ × 3′ 0″	1,725
,, ,, ...	12·6	285	160	5′ 6″ × 2′ 9″	834
Ernest Scott	4·8	380	80	6′ 0″ × 3′ 0″	267
Brush Company...	6·5	300	80	6′ 0″ × 2′ 8″	406
Silvertown	36 7	300	100	8′10″ × 4′ 3″	872
Napier Prentice...	11	550	100	— —	355

As regards the last-mentioned firm, their dynamos have only recently been put on the market. The peculiar feature is the armature, which is a Pacinotti Drum closed with metal covers at the ends, so that no wire is visible. The grooves between the teeth are covered with strips of bone, and the firm claim that these armatures are completely waterproof. On this point we must defer an opinion until a test by some independent authority has been made; but, judging from appearance, we should not be surprised to find that the claim of the designer will be realised in actual practice.

MR. RAIKES' influence at the Treasury must be very powerful to extract from that Department concessions to the telegraphists costing nearly a quarter of a million per annum, especially when a still more expensive revision is impending under the same auspices for the benefit of the postmen. It is, perhaps, too much to hope that the men will be satisfied; but they can hardly fail to be surprised at the liberality with which their demands have been met. Besides considerable extensions of the scale maximum of each class, a rate and a-quarter is to be paid for overtime, whilst duty on Sundays and Bank Holidays is to be paid for as overtime—a privilege which until now only the metropolitan clerks enjoyed. For all alike full pay will be allowed during sickness. Short of an abolition of the classes, which Mr. RAIKES very properly would not consent to, the telegraphists could hope for nothing better, and probably expected something less. It is satisfactory to notice that the female staff participate in these boons, although they have taken little or no part in the unseemly agitation which lately has discredited a certain section of the male staff.

PROBABLY the leading agitators will say that all this has been extorted under pressure of their organised terrorism. That is a matter of opinion—the truth perhaps is that all it has done has been to quicken the movements of the departmental Committee. But be that as it may, the exclusion of the more violent spirits to the number of nearly 200 from the benefits of this revision will have the effect of demonstrating that leadership of threatening movements like these in the public service is attended with no small risk. It is only to be regretted that the responsible ringleaders, like Mr. MAHON, will not get their deserts.

THE announcement that the Committee of the House of Lords has put its veto upon the Central London Railway Bill will, we think, be received, as the *Standard* expresses it, with "indignant surprise." The Bill was discussed for thirteen days before a Select Committee of the Lower House, and the conclusion then arrived at was, that the proposed railway was likely to prove a public benefit, and ought to be allowed. Such also was the general opinion of the House of Commons itself, if we may judge by the brief debate which preceded the third reading of the Bill. But the spectacle of the dome of St. Paul's emulating the Leaning Tower of Pisa, and of Oxford-street transformed into a grass-grown thoroughfare, which was conjured up by opponents of the scheme, seems to have carried great weight with the House of Lords' Committee; for, after deliberating for fifteen minutes upon the evidence, they decided that the preamble was not proved. It is, however, impossible to find fault with the reasons upon which this remarkable decision was based, for none were given.

THE electric lighting scare which was created in this country in the early part of the present year by the fatal accidents in New York, and the discussion of the *pros* and *cons* of execution by electricity, gave rise, as many of our readers will remember, to several questions in the House of Commons; and in April Sir MICHAEL HICKS-BEACH promised to obtain some reliable information as to the number of deaths in the United States due to the electric current. The American census office was not, however, in possession of the necessary data, and all that the Board of Trade has been able to secure are the results of some investigations which have been made by the municipal authorities of New York. From these it appears that from January 1, 1887, to May 15, 1890, there were only 16 deaths from electricity in New York City, and of this number no less than nine occurred amongst linemen or other electric light *employés*. Considering the manner in which so large a proportion of the electrical work in the "Empire City" has been carried out, an average of about five deaths per annum seems to us a very small one upon which to have started so great a panic.

M. HESS, in *La Lumière Electrique*, usefully calls attention to certain considerations in the design of resistances for strong currents. His remarks are opportune in view of the recent work which has been done on the heating effect of currents, and also in connection with the production of new materials of high specific resistance. In making coils for resistance tests the choice of a material having a low temperature coefficient is very important; but this is not usually the case with coils intended to stand strong currents, nor indeed is high specific resistance a desirable thing. M. HESS shows that if two coils of equal resistance are designed to stand the same current without rising above a given temperature, the coil of higher specific resistance is shorter, while the diameter and volume of

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the conductor are greater; the ratio in all three cases being the cube root of the ratio of the specific resistances. Thus, if the second coil has 27 times the specific resistance of the first, its length is one third that of the first, while the diameter of, and the volume occupied by, the wire are each three times as great. Unless, therefore, the second material costs only one-third that of the first, it is cheaper to construct the coil of the better conducting substance. This result is not very new, as Mr. W. H. SNELL discussed the question from the same standpoint, and arrived at similar conclusions in *The Electrician* of January 31, 1885. The fact is, however, likely to be overlooked, and is one which tends to discourage the search for new materials of very high specific resistance. Unless such substances are cheaper than the old ones they can be used with advantage in but few instances, even if their electrical behaviour is perfectly reliable.

THE LANE FOX negotiations have come to a dead-lock. The Company, which was formed, with a capital of £100, to collect royalties, has now realised that there is no hope of a simple recognition of the patents, and they are not prepared to make a test case. We are informed that they have, therefore, reversed their policy, and propose to let their property and its control go to the highest bidder.

IN another column will be found the judgment of the Scotch Court of Appeal in the compound-winding case, from which it will be seen that Lord TRAYNER'S decision, invalidating the Brush patent, has been upheld. We propose to deal with this important judgment at greater length next week.

Aberdeen.—The Aberdeen Electric Lighting Bill has been withdrawn.

Dorchester.—An electric lighting company has announced its intention of applying for a Provisional Order.

Perth.—The Scottish House-to-House Electricity Company have given notice that they intend to apply for a Provisional Order.

Litherland.—The local House-to-House Company has informed the Local Board of its intention to apply for a Provisional Order.

Penzance.—At the last meeting of the Town Council the Penzance Electricity Supply Company announced their intention of applying for a Provisional Order.

Newry.—The Town Commissioners have decided not to give their consent to the proposed Provisional Order of the Irish House-to-House Electric Lighting Company.

Telegraphic Communication with Bermuda.—The Post Office authorities notify that telegraph communication with Bermuda is established. The charge is 4s. per word.

Personal.—Herr Wilhelm Lahmeyer has severed his connection with the Deutsche Elektricitäts Werke at Aachen, in order to devote more time to experimental research.

Woolwich.—The London Electric Supply Corporation and the Woolwich District Electric Light Company have announced their intention of applying for Provisional Orders.

St. Moritz-Bad.—The large hotels are having a 4,000 light central station built for the 1891 season. The power will be derived from the Julierback in Silvaplana, where it has a fall of 35 meters.

Bridlington Quay.—The temporary lighting of the Parade, which has been undertaken by the Laing, Wharton, and Down Construction Syndicate, was successfully inaugurated on Saturday evening last.

Pembroke.—At the last meeting of the Board of Commissioners of this township, a letter was read from the Electric Lighting Company of Ireland, announcing their intention of applying for a Provisional Order.

King's College, London.—At a meeting of the Council of King's College, London, on Friday last, Mr. David S. Capper, M.A., Assoc.M.Inst.C.E., was elected to the Professorship of mechanical engineering at the college.

Dusseldorf.—A company has been formed by some energetic manufacturers, with the object of building tramways to connect the suburbs, Grafenberg, Derendorf, Rerth, &c., with the town. Electricity will be used as motive-power.

Keighley.—The Town Council has decided to oppose the applications of the Yorkshire House-to-House Electricity Company and the Electric Installation and Maintenance Company for powers to supply electricity within the borough.

Winchester.—At the last meeting of the Town Council, the General Purposes Committee reported that, in accordance with the resolution of the Council, they had invited proposals for lighting the city and municipal buildings by electricity.

Incandescent Lamp Manufacture.—Messrs. Fritsche and Pischon have built an incandescent lamp factory at Fürstenwalde, near Berlin, which is now nearly complete. A distinguishing feature will be a special type of air pump made by the firm.

Whitechapel Board of Guardians.—Notices have been received by this Board from the Laing, Wharton, and Down Construction Syndicate, the London Electric Light Supply Corporation, and the House-to-House Electric Light Supply Company, of their intention to apply for Provisional Orders.

The Electric Sugar Frauds.—Judgment was given on Wednesday in the New York Courts in favour of the English stockholders in the Electric Sugar Refining Company, who sought to recover some of their money by suing Messrs. Cotteril and Robertson, the president and treasurer of the Company.

Perpignan.—The civil tribunal at Perpignan has just condemned M. Bartissol, who has undertaken the electric lighting of the town, to pay 150,000 francs as compensation to a M. Campana for the damage done to his house by the noise, smoke, and vibration due to the proximity of the central lighting.

Leamington.—At the last meeting of the Town Council notices of intention to apply for powers to supply electric light in the borough were received from the Municipal and Electric Lighting Power Company, the Electric Installation and Maintenance Company, and the Midland Electric Light and Power Company.

Stretford.—At the last meeting of the Local Board, the sub-Committee, who have had charge of the question of electric lighting, said that the terms of a Provisional Order had been arranged with the Yorkshire House to-House Electricity Company, and recommended that the Order should receive the approval of the Board. The motion was adopted.

Berlin.—The arc lamps along the Unter den Linden have hitherto been connected 12 in series, and supplied by special machines in the Centrale Manerstrasse, giving 600 volts. As soon as the cables for the private supply of current in the above named street are laid and at work, the lamps are to be connected two in series across the ordinary mains.

University College, Bristol.—The autumn session begins on October 1st. The electrical engineering department, under Prof. J. Ryan, includes lectures and laboratory work, in a course covering three sessions. The chemical department, under Prof. Sydney Young, offers both daily and evening lectures. Further information will be found in our advertisement columns.

Dewsbury.—At the last meeting of the Town Council, the Gas and Water Committee reported that a letter had been received from an electric lighting company, giving notice of

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intention to apply for a Provisional Order. The Town Clerk reported that he had had an interview with the solicitor to the Company, and had informed him that the Corporation of Dewsbury intended making application, and would therefore oppose the Company's request.

Incandescent Lamps in the Colonies.—We draw the attention of our readers to the notice given by the Brush Electrical Engineering Company in our advertisement columns as to the use of incandescent lamps in Australasia, India, Natal, and the Cape. It appears that, having acquired the Edison lamp patents, the Company regard it as an infringement of the rights which they have secured, to import, sell, manufacture, or use *any* incandescent electric lamps in those territories.

Bath.—The difficulties in the electric lighting of this city appear to be nothing more serious than defects which occurred in the arrangement for raising and lowering the lamps. This has now been altered, and steps are being taken to fix the lamps and run the current direct to them without going through an intermediate switch, the constant removal of the lamps having allowed the water to enter. The lowering of the lamps by means of a cord was adopted in order to avoid the constant use of ladders.

The Interruption of the Australian Cables.—On the night of the 10th instant the three cables of the Eastern Extension, Australasia, and China Telegraph Company, between Banjoewangie (Java) and Australia, were simultaneously interrupted by an earthquake, the shock of which was felt an hour before on shore. Telegraphic communication with Australia, which was thus entirely cut off, is expected to be restored within a day or two, the ship being on the spot and momentarily expected to communicate on one of the severed cables.

The Electric Light in Night Attacks.—Sir Evelyn Wood, in his report on the night operations of the 10th inst., says:—"The night was dark and rain was falling when the general with the officer in charge arrived at the observation station of the electric light. The position was not favourable for observation. . . It was impossible to make out the nature of the bodies which were on the road. The light, however, was of great assistance to the picquets, enabling them to see along the flat road quite a mile in front of them."

Electric Lighting Orders.—In the House of Lords, on Tuesday last, Lord Balfour of Burleigh moved:—"That the Sessional Order of March 10th last, 'That no Bill brought from the House of Commons confirming any Provisional Order or Provisional Certificate shall be read a second time after Friday, June 27th next,' be dispensed with in respect of Bills to confirm Provisional Orders made by the Board of Trade under the Electric Lighting Acts, 1882 and 1888, and brought from the House of Commons on or before the 28th inst." The motion was agreed to.

Southampton.—Notices of intention to apply for Provisional Orders have been served on the Corporation by the Southampton Electric Light and Power Company; the National Electric Supply Company; the Electric Installation and Maintenance Company; and the South of England House-to-House Electricity Company. At the last meeting of the Town Council, the Lighting Committee recommended that the Southampton Electric Light and Power Company should be offered the sum of £750 for the transfer of the licence which they hold. After a lengthy discussion it was decided to refer the matter to a Committee of the whole Council.

Steno-Telegraphy.—The system of steno-telegraphy, which we fully described in our issue of the 4th inst., was tried on Thursday last week at the Palais Bourbon, in the presence of M. Floquet and the Secretaries of the Chamber. The wire on which the experiments were carried out had a length of about two miles and a half. M. Cassagnes stated that he had transmitted reports at the rate of 25,000 words an hour from Paris to Brussels; of 18,000 an hour to Lyons; and of 15,000 an hour to Marseilles. By means of his manifold system, M. Cassagnes claims to be able to supply simultaneously, with one instrument, all the papers of Paris with Parliamentary reports.

Electric Lighting Notices in the Metropolis.—At the last meeting of the London County Council, the Highways Committee informed the Council that notices of intended applications for Provisional Orders had been received from the St. James's and Pall-mall Electric Lighting Company for the parishes of St. James's, Westminster, and St. George's, Hanover-square; from the Westminster Electric Supply Corporation for the parishes of Paddington, Chelsea, St. Marylebone, Kensington, and part of St. Margaret and St. John, Westminster; and from the New Cadogan and Belgrave Electric Supply Company for the parishes of St. George's, Hanover-square, and Chelsea.

Obituary.—The death recently took place of Mr. Alexander Parkes, of Rosendale-road, West Dulwich. Mr. Parkes found his way at an early age to Messrs. Elkington's, where he devoted a large amount of attention to the details of the then newly-discovered process of electro-deposition. In 1840 improvements suggested by Mr. Parkes were combined in Messrs. Elkington's patent with the famous discovery of Mr. John Wright, who, by the use of cyanides of potassium, succeeded in producing firm and thick deposits of silver and gold by electro-deposition—then the great desideratum of the electro-plating process. His investigations were also directed very largely to the subject of the refining of copper. Mr. Parkes ultimately severed his connection with the firm, and received a large sum in recognition of the services which he had rendered. The invention of Mr. Parkes, which is of the most popular interest, is that of a substance which is now largely known under the name of celluloid or zylonite, but which was originally known as Parkesine.

A Central Station Struck by Lightning.—With regard to the central station of the Manhattan Electric Light Company, which, as we announced in our issue of June 13th, was struck by lightning, later information shows that the lightning did not strike one of the company's circuits and come into the building over the wires, but that it struck the roof of the building itself, and started a fire, which did the damage. The station supplies 20,000 incandescents and a large number of arcs. The damage done was confined to the dynamo room and the offices and store rooms. Out of about 30 machines only two or three escaped serious injury. The incandescent circuit switchboard was entirely destroyed. The arc-light switchboard was partially consumed. Every belt in the station was so badly burned as to require an entirely new outfit. The work of reconstruction was begun at once after the fire. The night after the fire about one-half of the arc lights and 12,000 incandescents were supplied with current as usual, while on the second night 17,000 incandescents were connected, and on the third night not far from 20,000 lights. The Company was able to make this fine showing, says the *Electrical World*, through the kind assistance of its very obliging business rivals.

Barnsley.—The Park and Lighting Committee of the Town Council have issued their second report on the subject of electric lighting. The question has been before the Town Council since September last. In November last the committee invited tenders, and received nine estimates from electric lighting companies to put down an installation in the inner area of the borough. The contractors were as follows:—The Gülcher (New) Electric Light and Power Company, £25,500; Electric Construction Corporation, Tender A, £22,751; ditto, Tender B, £21,721; Manchester Edison-Swan Company, £19,200; Westinghouse Electric Company, £17,800; Laing, Wharton and Down Construction Syndicate, £16,975; Electric Construction Corporation, Tender C, £15,108; Brush Electrical Engineering Company, £13,100; National Electric Supply Company, £11,888. The services of Mr. Bromley Holmes were secured to advise the committee. Mr. Holmes reported on June 7, and he further presented a detailed report on the Westinghouse Company's tender, recommending its acceptance. The report was discussed at a meeting of the Town Council on Tuesday, which adjourned, after three hours' discussion, for a fortnight. There was a strong feeling in favour of the adoption of the electric light, provided the price could be reduced

A Messenger Call System for London.—A *conversazione* was given on Saturday evening last by the Boy Messengers

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Company at the Royal Institute of Painters in Water Colours, for the purpose of exhibiting in miniature the system of messenger calls which that Company is seeking to introduce into the metropolis. Signalling apparatus, provided with suitably marked dials, will be installed for a nominal rental in clubs, hotels, theatres, shops, warehouses and other places of business, and will be in connection with the nearest messenger depôt. The instruments are arranged in series, as many as 100 being placed on one line if necessary. The closed circuit system is employed and the signals from the transmitters are received at the depôt by a Morse embosser. The movement of any one of the levers, which are arranged under the dials of the transmitters, actuates a series of ratchet wheels, causing them to rotate and bring the appropriate wheel into contact with a pawl, the movements of which make and break the circuit. As the ratchet wheels are each differently indented, the result is that the requisite Morse signals are transmitted to the receiving station. To ascertain whether a signal is already on the line, it is only necessary to press a push-button. This throws an electro-magnet into circuit, and if a signal is being sent from any other transmitter of the series the tapping of the armature of the magnet will announce the fact. The present system was originally introduced into this country by Captain Davies, of the Exchange Telegraph Company, and it is needless to say that something similar has been for years in successful operation in New York.

The Rise in Platinum.—Dr. Day, chief of the Geological Bureau, of the United States, attributes the great increase in the value of platinum chiefly to the increased cost of its production at the mines, there being no reason to suppose that the natural deposits are giving out. Hitherto the placers of Nishnee-Taglisk and Goro-Blagodat, in the Ural Mountains, have been richly productive of gold, and the owners of the mines could afford to sell the platinum incidentally obtained for a very moderate price. But now the gold has become scarce, and they are forced to depend to a greater extent upon the platinum for their profits. Of that metal, happily, there is plenty left. Thus it is seen why platinum has doubled in value within a twelvemonth, and is still rising, with no prospect of going down again. A great number of labourers have been drawn from the mines to build the trans-Siberian railway. This, for a time, lessens the production of platinum. At present the large dealers are buying up all the old platinum they can lay their hands on, in anticipation of a future rise in prices, so that a "corner" seems to be arriving in the commodity. This increase in the cost of platinum is of greater importance when it is considered how greatly the use of this metal has increased of late. It will probably never again be half so cheap as it was a year ago. In view of the scarcity of platinum, the Paper by Dr. Wahl, an abstract of which is concluded in another column, will be read with interest. The subject becomes of considerable commercial importance, since, for many purposes, a well-plated article should be as serviceable as one made entirely of platinum.

Attack on a Cable Station.—The following extract from a letter recently received from an officer of the West African Telegraph Company will, we think, interest many of our readers, and especially those who are unacquainted with the difficulties and dangers under which telegraphic work has frequently to be carried on in these out-of-the-way cable stations:—

Kotonou Station, May 1st, 1890.

. . . Our friend the King of Dahomey is, I am glad to say, about to receive a well-merited lesson. Last year, when I was in London, and told you something about the little games of these gentry, I thought the day could not be far distant when all that they had inflicted on us and the rest of the world would be repaid with interest. Last December I asked the Company to supply us with arms, as the blood of "Messieurs les Dahomiens" was visibly warming, a phenomenon by no means surprising, considering our proximity to the sun. But what gives me particular pleasure to relate is that His Majesty Bedazin "Osu Bowélé," which, being interpreted, means "King Shark," who swore he would paddle his own canoe in our blood, failed to keep his word; and I have no hesitation in saying that I prefer working for the W. A. T. to serving as a burnt offering to my friend Bedazin. We had *our* turn on the 4th March. The station was surrounded by the natives, and we were under the painful necessity of sending a few of them across the Styx. Seriously speaking, however, the station was for a time in imminent danger; Orsini and I fired more than 250 rounds each, and the 35 Senegalese sharpshooters who helped in the defence, fired some 120 rounds apiece. An artillery sergeant, who worked our two guns, was killed, and the white gunners were so hard pressed that they had to club their rifles. This racket began at 4 in the morning. At 9 a.m. we left the soldiers still firing, and went to the instruments, and you may imagine what a dance the mirror led us. By 10 o'clock, however, all was quiet in our neighbourhood, and the messages had all been sent through . . . I must not forget to tell you that we had to do with the famous Amazons. They were very fine creatures, fought like wild beasts, and were worth ten men.

Electricity in Mines.—The following are some particulars relating to an electric haulage plant installed at the Erie Colliery of the Hillside Coal Company, at Scranton. The power plant consists of a 60 horse-power Armington and Sims engine, and a 50 horse-power Thomson-Houston dynamo, wound for a current of 220 volts potential. The engine and dynamo room are at the top of the shaft. From the dynamo to the foot of the shaft the current is conducted by wires, enclosed in gas pipes to protect them from damage. From the bottom of the shaft the wires are carried overhead about 12in. outside of the low rail of each track, and are suspended from an insulator specially designed for this class of work. Wherever turnouts occur frogs are used, the conductors being soldered to them in the same manner as when used for street railway work. Connections from the mains to the overhead conductor are made at suitable intervals, and a portion of the current is utilised for lighting purposes, two 110-volt lamps being placed in series. The rails are used as conductors for the return current. The locomotive is of the following dimensions:—Length over all, 9ft. 7in.; width, 5ft. 3in.; and height, 5ft. 6in. This last dimension can be considerably reduced by placing the rheostat at one end instead of on the top, as has been done in the present instance. The weight of the locomotive is 10,500lb., to which 1,800lb. has been added to increase traction. The motor employed is of 40 horse-power. During a period of 11½ days the average number of cars delivered at the shaft bottom by the locomotive was 559·5, against 526·95 per day delivered by mule haulage. To deliver 700 cars per day of 10 hours, the time of running the locomotive would be 5 hours and 30 minutes, leaving 4 hours and 30 minutes for contingencies. The total distance run would be 21·28 miles, and the locomotive would be reversed 232 times.

The Pay of Telegraph Clerks.—The revised regulations relating to the Postal Telegraph Clerks have just been issued by the Postmaster-General to date from 11th inst. The service of provincial sorting clerks and telegraphists is divided into four groups. The first group contains six towns of the first importance, in which collectively 2,186 men and 753 women are employed. It is now decided to raise the scale of pay here for men, from 40s. per week, with annual rise of 2s. to 50s., to a *maximum* of 56s. in the first class, and from a *minimum* of 12s., with rise to 38s., to a *maximum* of 40s. in the second class. For women in this group the existing pay in the first class is 27s., with annual rise of 1s. 6d. to 32s. This will be altered to 28s., with rise to 35s., while in the second class a rise of 2s. on the present maximum is accorded. In the second group, comprising five offices, where 765 men and 172 women are employed, the maximum is raised from 50s. to 54s. in the first class, and from 38s. to 40s. in the second class, for men, while the rise is from 32s. to 34s., and from 26s. to 28s, in the first and second classes for women. In group 3, comprising eight offices, 824 men and 102 women are employed, who in both classes receive an increase, the men of 2s. and the women of 1s. to their present maximum rate of pay. Group 4 comprises 26 offices, in which 1,618 men and 177 women are employed. In the first class of this group the maximum is not raised, though in the second class it is raised by 2s. for both men and women. Of the London male telegraphists—to the first class, who are now on a scale rising to £140, an increased maximum of £20 has been accorded, while the top pay of the second class is raised from £100 to £110; while the female telegraphists have been granted a rise in similar conditions of 4s. per week in the first class and 3s. in the second class. In addition to this, further advantages have been accorded to the staff throughout the country in the matter of overtime, Sunday work, Bank Holiday work, pay for which will be allowed in the provinces as well as in London. Pay during sickness is accorded to all alike. All overtime is to be paid for at a rate and a quarter.

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ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 261.)

§ 4. **Ganz Transformers.**—Proceeding next to the transformers, we may mention, in passing, the old life-buoy shaped transformer of Zipernowsky merely to point out that it is no longer used in practice. In that early form the primary and secondary coils were wound in circular coils, then laid together, and wound over with iron wire so that the whole arrangement

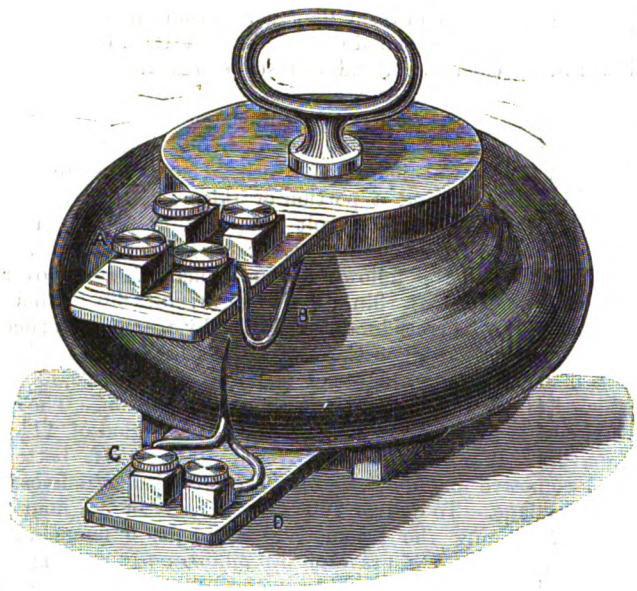


FIG. 8.—Old Form Zipernowski Transformer (1885) not now used.

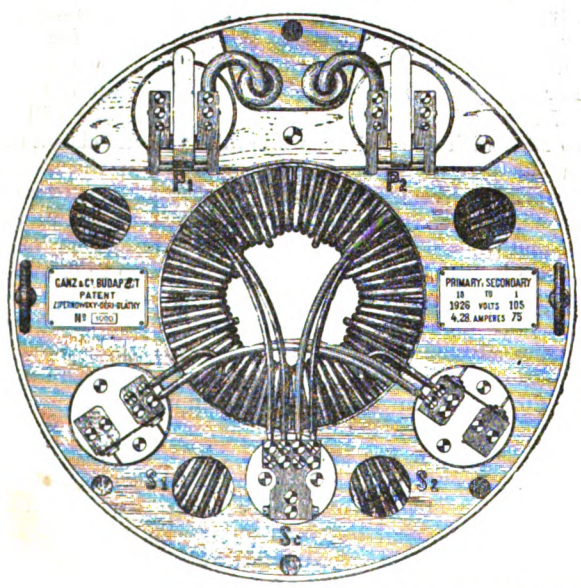
looked like a stout circular ring. (*See* Fig. 8.) This form possessed a multiplicity of disadvantages. The heat generated in the coils themselves escaped with great difficulty. The magnetic resistance of the iron circuit was considerable, and any damage to the coils or insulators could only be repaired by taking the whole apparatus to pieces with great labour. Hence this type of shell transformer gave way to a more practically useful form. In the latest form, a series of sheet-iron discs like flat thin rings, are stamped out; these are built up with interposed paper layers into a circular ring of laminated iron, having a square or rectangular cross section. These discs are held together by radially placed clamping plates (*see* Figs. 9), which divide the ring core into partitions. The primary coils are then wound on the ring, covering it uniformly, and the secondary wire is put outside the primary. Iron discs top and bottom enclose the core and serve as supports for the terminals and fuses. The transformer roughly resembles a water-wheel, and can be rolled about easily when set on edge. On the top plate are fixed porcelain discs, which carry the primary and secondary fuses, which are short slips of fusible metal contained in glass tubes. The transformers are made in various sizes, to transform down generally to 105 and 52 volts, and each secondary circuit has three terminals by which 105 volts can be taken off for incandescence lamps, and 52 volts for arc lamps. The transformers are made in four sizes as follows:—

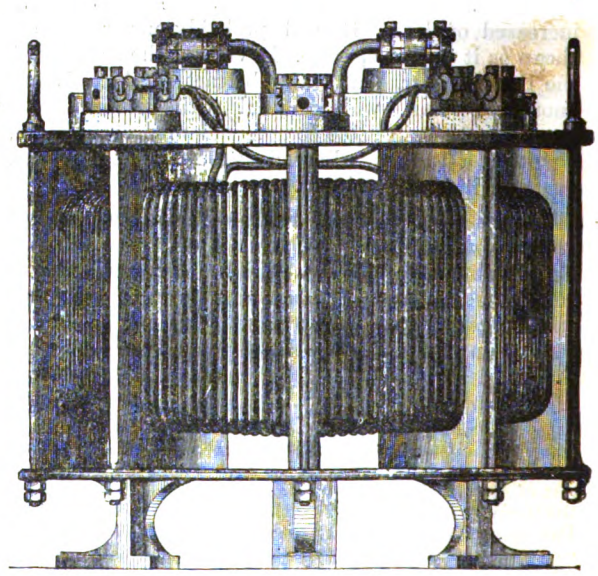
Ganz Transformers.

No.	Output in watts.	Weight in kilogrammes.	Commercial efficiency at full load as given by makers.
1.	1,875	70	92·5
2.	3 750	110	94·5
3.	7,500	180	95·5
4.	15,000	290	96·8

The energy loss in magnetizing the iron is stated to be 5·5, 3·5, 2·5, and 1·5 per cent. respectively at full load in the No. 1, 2, 3, and 4 sizes, and the energy loss in the copper is put at 2 per cent. The primary coils are wound to receive current at 900, 1,800, 2,700, and 3,600 volts respectively in the four sizes, and to transform it down to 105 and 52 at the chief and intermediate terminals on the secondary circuit. The relation in commercial efficiency to the load on the secondary circuit of watts is given by the efficiency curve, as shown in Fig. 10.

This curve is given only on the authority of the manufacturers, but its general accuracy is probably sufficient for the purpose of reckoning the efficiency of the transformer at various loads. It has been confirmed fairly well by the independent tests made by the Frankfort-am-Main Committee in 1890. This committee found that the latest pattern of Ganz transformer had at full load an efficiency of 95 to 96 per cent., at half-load 93 to 94, at quarter load 90, and at eighth load 80 per cent. efficiency. (*Electrician*, Vol. XXIV. (1890), p. 439.)





FIGS. 9.—Ganz Transformer (Zipernowski, Déri, Bláthy), 1890.

The experiments of M. A. A. Roiti,* to be again referred to later on, have also shown the efficiency at full load of a 3,800-watt Ganz transformer to be from 94 to 96 per cent.; but we defer to another chapter the full discussion of the

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* See *La Lumière Électrique*, March 15, 1890, Vol. XXXV., p. 525.

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methods by which these values have been arrived at. It is desirable, however, to make here a brief reference to some misleading conceptions which often surround the question of the efficiency of transformers in practical use. It has been frequently pointed out that there is a great difference between the *instantaneous efficiency* of a transformer at any moment, and the *mean efficiency* over any period such as 24 hours, during which it is loaded to very various degrees. The difference between these efficiencies may be considerable, the mean efficiency being often very much less than the maximum efficiency, and depending on the way in which the transformer is used. Given, however, a definite load curve—that is, a curve showing the load in watts on the secondary of the transformer at short intervals of time during the day, and an efficiency

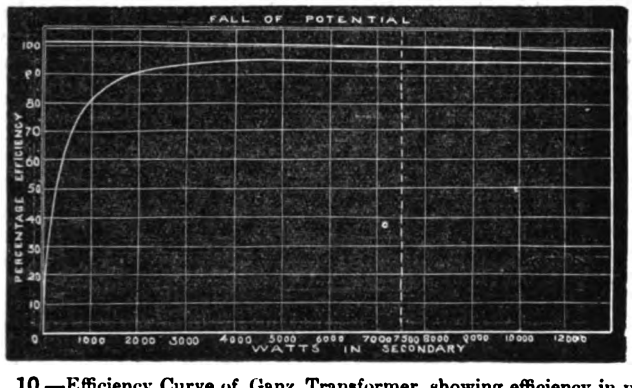

Fig. 10.—Efficiency Curve of Ganz Transformer, showing efficiency in per cents in terms of secondary load.

curve such as that in Fig. 10—the mean efficiency may be deduced as follows:—

Let the ordinates of the firm-line curve in Fig. 11 represent the secondary load in watts, or the lamp-load on the transformer, at the various hours of the day. Increase each hourly ordinate of this curve in the ratio of 100 to the number

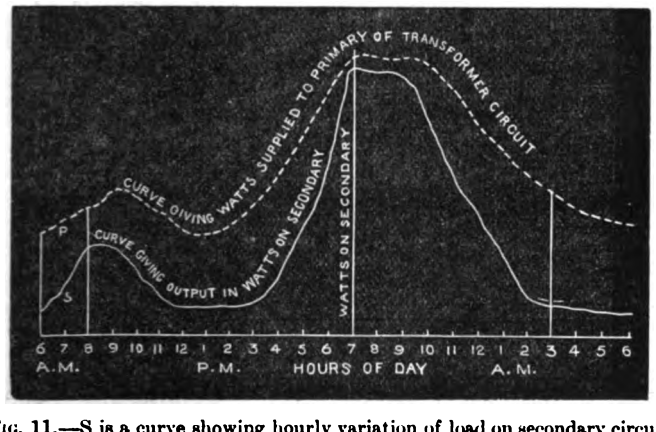
CURVE GIVING WATTS SUPPLIED TO PRIMARY OF TRANSFORMER CIRCUIT
CURVE GIVING OUTPUT IN WATTS ON SECONDARY
WATTS ON SECONDARY
P
S
6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6
A.M. P.M. HOURS OF DAY A.M.

Fig. 11.—S is a curve showing hourly variation of load on secondary circuit in watts. P is a curve showing corresponding variation of watts supplied to primary circuit.

denoting the efficiency of the transformer corresponding to the actual secondary load at that hour, which can be done from the efficiency curve giving the relation between efficiency and secondary load. Also if at any hours the secondary circuit is open and the secondary load therefore zero, ordinates must be set up at these points on the same scale proportional to, and representing, the power in watts absorbed by the transformer when the secondary circuit is thus open. Let the new higher ordinates define a curve shown by the dotted line. Then the ratio of the whole areas included between the two curves, firm and dotted, and the base line is a fraction which denotes the *mean efficiency* of the transformer during the twenty-four hours. If the load diagram varies from day to day, a further comparison of the daily mean efficiencies must be made to obtain the real average mean over any period of time, such as a year. It follows that a high efficiency at full load will not give a high mean efficiency unless the efficiency curve of the transformer rises from zero very rapidly to its greatest ordinate. A transformer may have a very high efficiency at full load; but if it absorbs, when the secondary circuit is open, a sensible amount of power, and stands idle twenty hours out of twenty-four, its real commercial efficiency may be brought down easily to 60 or 70 per cent. or less. Further remarks on the bearing of this fact on the economy of working of transformer stations will be reserved until later. In central-station work done by this firm the 7·5 unit, or 7,500 watt transformer, is a very favourite size. The usual practice with Messrs. Ganz and Co. is to "bank" a number of transformers when a large secondary output is required, so arranging them that the primary circuits are all in parallel between the primary mains and the secondary circuits all in parallel with the secondary mains, and then to connect or disconnect transformers according as a larger or smaller output is required. In placing the transformers four methods are adopted. The transformer when one only is

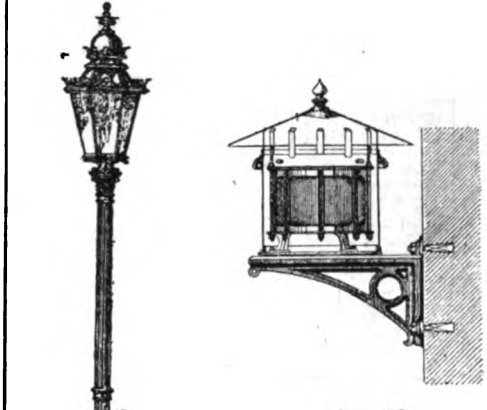

Fig. 12.

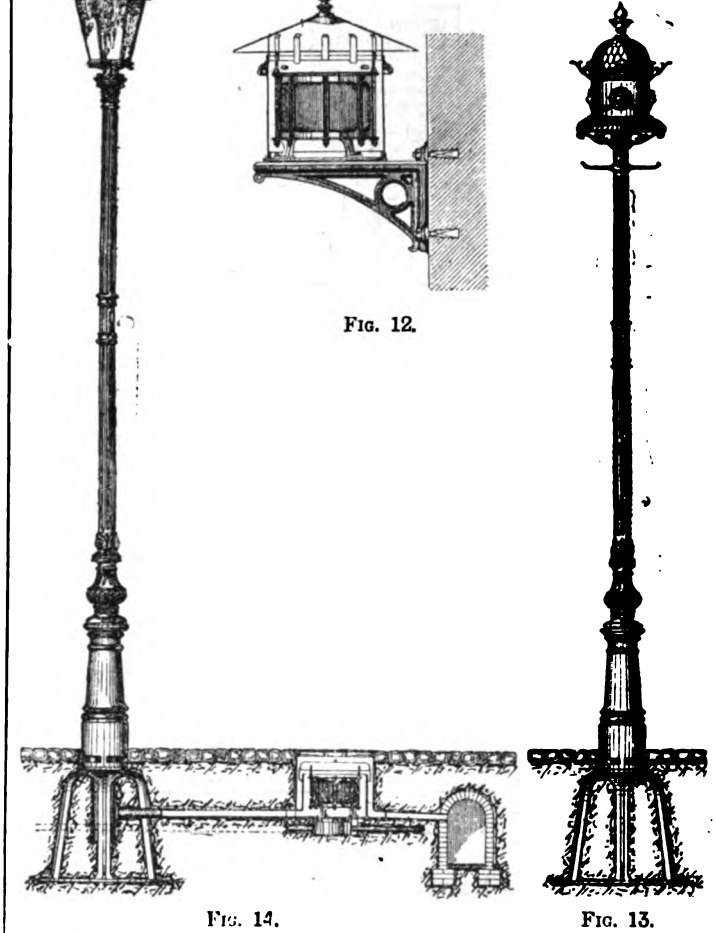

Fig. 14.

Fig. 13.

required at a place can be placed on a shelf enclosed in a weather-tight iron box (*see* Fig. 12), or it may be perched up on an iron pole like a dovecot, an ornamental form being given to the transformer case (*see* Fig. 13), or it may be buried in a watertight iron box (Fig. 14), or some small fireproof dry room in the building to be supplied with current may be set apart as a transformer house, and in which the transformers are arranged on porcelain insulators, on stone or wooden shelves, or resting on iron rails. This latter plan has much to recommend it in the facility it affords for getting at the transformer.

§ 5. **Pressure Regulating Devices.**—If an alternating-current dynamo is supplying current to a group of distant transformers through a cable laid between the localities, and if the load on the secondary circuits of the transformers varies, then the primary current flowing through the supply conductor will vary also. In order that the electric pressure at the terminals of

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the secondary circuits of the transformers may be kept constant in value, it is sufficient and necessary that the pressure between the primary terminals of the transformers be maintained at a constant value. Assuming that the primaries of the transformers are arranged in parallel between the primary conductors it follows that whatever may be the variation in the primary current, the pressure between the terminals of the primaries of the transformers must remain the same. If the resistance of the cable is R ohms, and its self-induction negligible, and if V is the potential difference between the terminals of the alternator, and v is the potential difference between the terminals of the primary coils at the far end of the cable, then the current in the cable in amperes is approximately equal in magnitude to $\frac{V-v}{R} = C$. Hence, we have $v = V - C R$, and if v is to be kept constant, then it follows that as the strength of the primary current C varies, the potential difference at the terminals of the alternator must vary also, but so that the quantity $V - C R$ remains constant in value. The pressure at the terminals of the alternator must therefore not be maintained constant, but fluctuate with every change in the load on the transformers at the far end of the cable. It has already been pointed out that with the arrangements adopted by Messrs. Ganz and Co., this can be achieved by regulating the strength of the field-magnet current of the excitors; and MM. Zipernowsky, Déri, and Bláthy, have devised an exceedingly ingenious method for regulating automatically the magnetising current of the excitors, in such a manner that the quantity $V - C R$ is kept constant for all values of the secondary loads. The arrangement adopted is called an automatic regulator, and is placed in the central station in some convenient position. It is diagrammatically represented in Fig. 15. A is the alternator, and L_1 L_2 the primary leads, or cable proceeding out from the station. In some convenient position in the station are placed two transformers, T_1 and T_2, called respectively the Shunt and the Series Transformers. The primary circuit of the Transformer, T_1, is placed in parallel across the leads L_1 L_2, and the primary of the Transformer, T_2, is placed in series in one of the leads, L_2. The secondary circuit of T_2 is closed through a suitable resistance, R_2, and the secondary circuit of T_1 is closed through a solenoid, S, and resistances T, R_1 and R_2 as shown; the transformers T_1 and T_2 being so joined up that the secondary electromotive forces in T_1 and T_2 oppose one another as far as producing a current in the solenoid S is concerned. The potential difference between the terminals e and d of T_1 is proportional to the potential difference V between the terminals of the alternator. The potential difference between the points a and b is, or can be, made nearly proportional to the magnitude of the primary current in L_2, and hence to the fall in volts along the cable or to C R. Hence the potential difference between c and b or between e and f can be made proportional to $V - C R$ or to v, the primary pressure at the primary terminals of the transformers. If a voltmeter Vl is joined up between e and f, this voltmeter can be made to read the same value as a voltmeter placed across the secondary terminals of the transformers at the far end of the line. For this pressure at the secondary terminals is proportional to v, the pressure at the primary terminals. Hence the voltmeter Vl can read the pressure at any instant on the lamp circuits, although it is in no way connected directly with them. This voltmeter always indicates a pressure proportional to $V - C R$, which quantity it is necessary to keep constant.

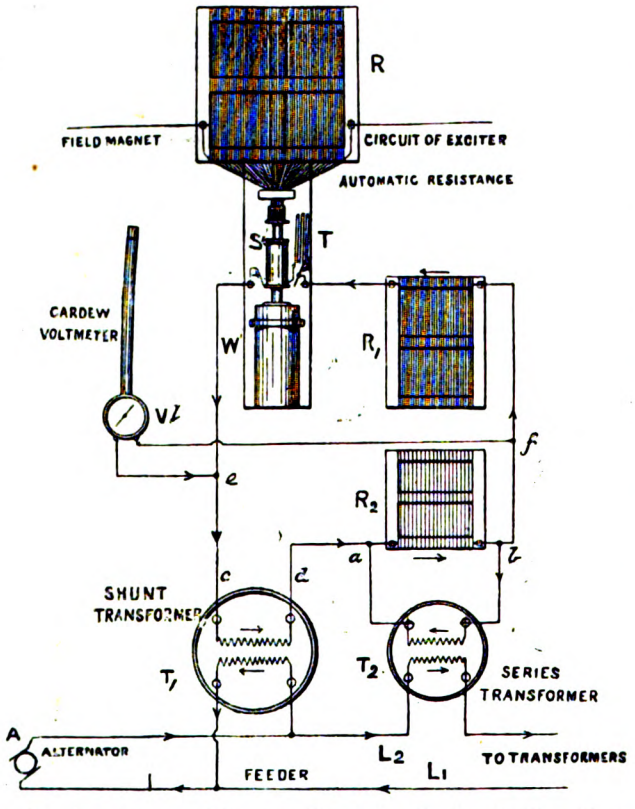

Fig. 15.—Arrangement of Pressure-Regulating Devices in Ganz System.

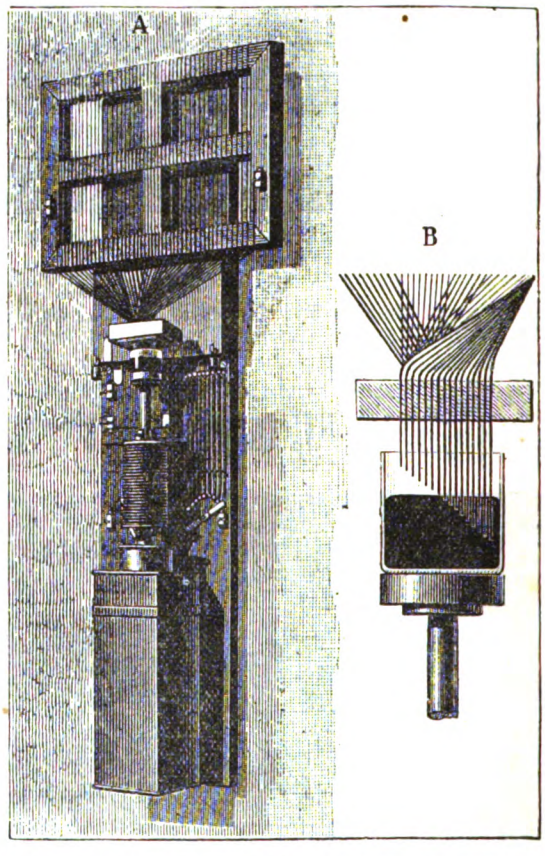

Fig. 16.—Mercury Cup, Float, and Solenoid in Ganz Pressure Regulator

The solenoid S is therefore traversed by a current, which is thus controlled in strength by the outgoing main current C and the terminal pressure V of the alternator. This solenoid is traversed by a tube or rod, partly of iron and partly of brass, the iron part so situated that a current in the solenoid tends to draw it up into the solenoid. This rod is held between guide pulleys, so that it can move quite freely through the solenoid. It carries at its upper end a glass cup full of mercury, and at its lower end is a metal float, by means of which its weight is taken up when the float is immersed in a vessel of water. The diagram in Fig. 16 shows clearly the nature of these arrangements. Above the mercury cup is situated a resistance coil of iron wires, and the terminal wires of the sections into which this coil is divided are brought down into a group of iron wires bevelled off like pan-pipes, and so fixed in a block as to dip into the mercury in the cup (B, Fig. 16). It is easily seen, therefore, that as the mercury cup rises and falls it immerses a greater or fewer number of iron wires, and more or less of the coils on the resistance coil will be short-

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circuited by this immersion. This resistance coil is in the circuit of the field-magnet coils of the excitors; and hence as the mercury cup moves up or down in obedience to a greater or less attractive force of the solenoid upon the iron rod carrying that cup, so the field strength of the excitors is varied.

The connections are made so that if the current in the solenoid circuit, which is proportional in strength to V—C R, increases, the mercury cup is drawn down, and so intercalates resistance in the fields of the excitors and decreases the strength of the field of the alternators, and *vice versâ*. There is a small rheostat or resistance T in series with the solenoid S, by which large variations of the current in the solenoid can be made by hand, and in the same way large amounts of variation of the fields of excitors can be made by a hand-regulated resistance; and the automatic arrangements then can be set to keep the pressure at the far ends of the feeders constant within a given amount, so as to be independent of the changes of load. The above arrangement may seem at first rather complicated, but it does its work in practice very well, and its practical operation shows it to be one of the few devices of this kind which can be considered to be a thorough success.

The above described elements constitute the distinctive features of the transformer system elaborated by MM. Zipernowsky, Déri, and Bláthy, and we proceed to describe some of the central stations operated by the aid of these devices.

(To be continued.)

REVIEWS.

Practical Electricity in Medicine and Surgery. By G. A. Liebig, jun., Ph.D., Assistant in Electricity, John Hopkins University, &c., and George H. Rohé, M.D., Professor of Obstetrics and Hygiene, College of Physicians and Surgeons, Baltimore, &c. (London and Philadelphia: F. A. Davis.)

The authors of this work very rightly remark in the preface that "A treatise on medical electricity . . . should be eminently practical, and should deal with such matters only as have a direct bearing upon the requirements of the practitioner. The book should be free from unnecessary technicalities, and only so much attention should be devoted to theory as is demanded in the explanation of such phenomena as are presented in the medical and surgical uses of electricity." Although an attempt is made on a subsequent page to justify a departure from this excellent principle, we cannot help thinking that Drs. Liebig and Rohé would have produced a far more useful work had they adhered a little more closely to their original opinion.

The book is divided into three parts, of which the first deals with the general principles of electricity and magnetism, while the second and third parts are devoted to an account of electrophysiology and therapeutics.

In common with many other writers on the subject, the authors appear to have assumed, at the outset, that, as a rule, medical men are profoundly ignorant of the veriest axioms of electricity, and hence the book commences with a lengthy description and explanation of the effects produced, by rubbing together "a piece of glass and a stick of resin, or a piece of ebonite and a silk rag." Subsequently, a tendency is shown to form a somewhat higher estimate of the capacity of their readers. Allusions are made to "sines," "shunts," and "torsion," and we are treated to pages of formulæ and to abstruse explanations of equally abstruse laws, the practical application of which to the subject of medical electricity it is somewhat difficult to determine; nor are we assisted in doing so by any very definite references to these formulæ and laws in subsequent parts of the work. As an instance of the unpractical character of this part, we would point out that no less than seven pages are devoted to the consideration of various forms of galvanometers; the student is then met with the somewhat *naïve* remark that "those galvanometers which have heretofore been mentioned are intended almost exclusively for laboratory purposes!"

Whether or not the profound ignorance to which we allude actually exists (which we doubt), we cannot help thinking that the attempt to combine in the short space of some hundred pages or so, an elementary treatise on electricity, with explanations of the more complicated questions which arise, is, to say the least, unfortunate, and leads to a crudeness and want of perspicuity which seriously detract from the merits of the whole work. The chapter dealing with "Batteries and Cells" is, as far as it goes, a considerable improvement on the two preceding chapters, but even here we notice the same unpractical tendency. The Daniell, the Grove, and the Bunsen cells are excellently figured and described, but we can find no allusion in this part of the work to the bichromate cell, nor to the well-known and popular Leclanché element. This omission is the more apparent, because, on page 220, the Leclanché cell is referred to as being one that "fulfils most of the desiderata" of a stationary battery; and on page 227, the opinion is expressed that, in spite of their "shortcomings, the bichromate batteries remain, at present, our best type of portable batteries." The account given of the principles and mode of action of "storage electricity" is clear and valuable; very rightly, exception is taken to the use of the word "storage," as conveying a misleading impression of the *modus operandi* of such batteries, but the word is retained in deference to popular opinion.

It is hardly necessary in these columns to express in detail our opinions upon Parts II. and III., dealing, as these Parts do, more particularly with electro-physiology and therapeutics. They appear to be well written and concisely expressed, and should, we think, be of considerable value to the practitioner. We cannot, however, fail to be struck by the apparent independence of these two Parts of the work upon the Part immediately preceding. To all intents and purposes the perusal of the electrical sections in any standard work upon natural philosophy or physics might, and we think with advantage, be substituted for Part I.; and yet Parts II. and III. would still be readily understood, and possibly more fully appreciated. The last hundred pages of the work are devoted to the methods which have been employed in the application of electricity in various diseases. The list of diseases is somewhat a portentous one; to us it appears that there are but few of the troubles which "human flesh is heir to" but have been more or less successfully alleviated by the use of electricity. In many cases the improvement seems, as far as we can judge, to have been due solely to the electrical applications; in others, and notably in the case to which the plates facing page 372 refer, the electricity has been associated with other powerful remedies, and it is therefore very difficult to determine exactly the amount of credit due to each.

The book is well got up and excellently printed; the illustrations, which are very numerous, are many of them original, while others are derived from such well-known sources as Erb's "Elektrotherapie," von Ziemssen's "Elektricität in der Medicin," &c. The value of the work would be enhanced by the introduction of a fuller index, which might also be made to do duty as a glossary, or a separate glossary should be added.

Technology Quarterly. May, 1890. Massachusetts Institute of Technology, Boston.

The Paper on "Tests of Incandescent Lamps," by Mr. Puffer, which concludes this number, contains little that is of interest, even to the lamp-maker. The diagrams to show the distribution of the light are arranged to overlap each other in a very confused way, apparently to save space. Going backwards, there is a brief article on an early form of Pentane lamp, and an article on the engineering laboratories of the institute. These appear to be splendidly equipped with numerous testing machines, tanks, and extensive apparatus for hydraulic experiments, a triple-expansion experimental steam engine of 150 horse-power, besides other engines of 80, 40, 16, and 8 horse-power dynamometers, cotton machinery, looms, and many other important machines, besides class-rooms, and drawing offices. The first two items of the number are of very great value; the one, a lecture on "Some of the present aspects of Education," by the late W. P. Atkinson, and

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the other, a short memorial of the author. For beauty of style, and for a quiet and impartial tone in handling the merits of classical and technical education we have rarely seen its equal. Much has been written in our periodicals in a didactic and sometimes in an aggressive spirit, and we strongly recommend all who are interested in educational matters to study this admirable lecture, for which some rather superfluous apologies are made by the editor.

At the risk of spoiling the literary value of the whole, we propose shortly to extract those parts which bear directly upon scientific education.

The Wimshurst Electrical Influence Machine. By WILLIAM PHILLIPS MENDHAM. (Bristol: King, Mendham and Co.)

This is an illustrated brochure of about 60 pages, briefly describing the action of the Wimshurst machine, and giving a few practical hints with regard to its management. The greater portion of the book is taken up with descriptions of the experiments which can be performed by aid of this machine. It is to be regretted that the author has confined himself entirely to an account of the usual popular lecture type of experiments.

Turning Lathes: a Manual for Technical Schools and Apprentices. Edited by J. LUKIN, B.A. (Published by the Britannia Company, Britannia Works, Colchester.)

This little book is very clearly written, and will have a wider sphere of usefulness than that suggested by its title. The author has treated his subject methodically, starting from the very beginning, and keeping constantly before his reader the need of patience and care in detail when commencing lathe work if any real proficiency is to be attained. While embracing wood and metal turning, and giving a chapter on metal-spinning, it is the elementary details of each to which special attention is paid; and the aim of the author has been to explain the sources of disappointment to the beginner, and how his difficulties may be avoided and overcome. Anyone who thinks he has only to buy a lathe with a compound slide rest in order to turn out good work is warned off, and he is told very plainly that if he wish to succeed he had better buy a cheap lathe, and master wood-turning by hand before he uses the rest. In fact, no one is encouraged to buy a lathe unless he really means to take the trouble and give the time to master the instrument. The difficulties to be overcome before satisfactory work can be turned out are insisted on, one might almost say, to a disheartening extent, were it not that the best method of overcoming these difficulties by practice, and using thought with the tools, are pointed out at the same time. Many little hints for making apparatus and devices by which the use of costly tools may be avoided are given, which will be useful to many besides the tyro. It is rare to find a book written for beginners by an author who is master of his subject without his presupposing they possess some of his knowledge.

THE EFFICIENCY OF THE TRANSFORMER.*

BY CALVIN HUMPHREY AND WILLIAM H. POWELL.

The results presented in this Paper are supplementary to the work of Prof. Ryan and Mr. Merritt in the same line, presented to the Institute last December. The 10-light transformer which they tested was found to have a remarkably heavy loss on open circuit, which was shown to be due almost entirely to hysteresis in the iron. The transformer gave an efficiency of 86 per cent. at normal load and an "all-day" efficiency of about 40 per cent.

In our work on a 40-light transformer of the same design (the two coils placed side by side in a core of laminated plates, *see* Fig. 1), but of more recent manufacture, the loss on open circuit was found to be about one-half as great as in the 10-light transformer. Its efficiency reached 96·2 per cent. at normal load, and the "all-day" efficiency would be about 90 per cent.

The method employed in the work is substantially Prof. Ryan's method. The instantaneous values were obtained by means of a commutating device, attached to the alternator. This device consisted of a wooden disc, mounted rigidly on the shaft of the alternator, with a steel contact at one point in its periphery, which made contact with a small piano wire brush once every revolution. The holder carrying the piano wire brush was attached to a pointer, which moved over a scale and indicated the position of the brush for a given reading. Then, evidently, if the brush which completes the circuit through the contact be altered in position, values can be obtained for different points on the curves of E.M.F. and current.

A quadrant electrometer was used to measure the primary E.M.F., secondary E.M.F., and primary current. A condenser was connected in parallel with the electrometer. The primary current was measured by the fall of potential through incandescent lamps placed in series with the primary of the transformer. These lamps were carefully calibrated at different temperatures. Then, knowing the resistance of the lamps and the potential difference at the terminals, the current flowing at once becomes known.

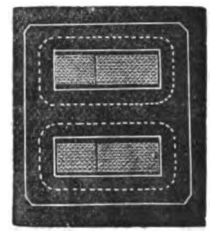

FIG. 1.

To measure the primary E.M.F. twenty-two 50-volt lamps were placed in series across the primaries. The electrometer was connected around two of these lamps, and the whole number calibrated, in order to know what part of the total impressed E.M.F. was measured. The secondary E.M.F. was measured direct. The secondary current was measured by means of an electro-dynamometer, which was carefully calibrated both before and after the experiments, and was found to be constant. The commutating device was placed in series with the electrometer.

In obtaining the Ewing curve of hysteresis of the iron core of the transformer, current from a storage battery was sent through the secondary circuit, and the magnetisation set up in the core was measured by the *kick* on a ballistic galvanometer in the primary circuit. The current in the secondary was gradually increased until the intensity of magnetisation corresponded with the maximum magnetic density of the transformer when working on a 1,000-volt circuit. The current was then decreased gradually until zero was reached. It was then reversed and the method continued until a complete cycle of magnetisation had been covered.

It is worthy of mention that this method, which gives something so definite and fundamental in the treatment of the alternating current, has only come into use within the past year, and the task of getting true instantaneous values of the complete waves of E.M.F. and current, which has always been considered too tedious for ordinary patience to deal with, was accomplished with ease in this work in 45 minutes. A calibrated scale for the electrometer readings added very much to the facility with which observations could be taken.

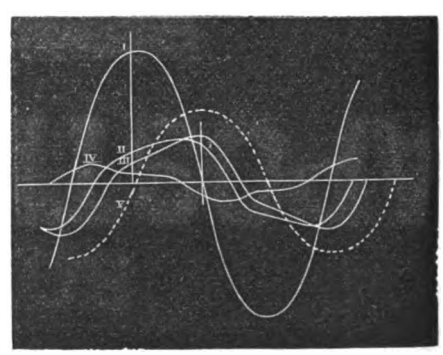

FIG. 2.

I. Primary E.M.F. [maximum 1,300 volts].
II. „ Current [maximum 0·11 amp.].
III. „ „ with Foucault currents eliminated [max. 0·12 amp.].
IV. Foucault current component [maximum 0·05 amp.].
V. Curve of magnetisation.

The marked improvement of the 40-light transformer over the 10-light is due, we believe, to an improvement in the magnetic properties of the iron and a fewer number of turns in the coils, made possible by the better grade of iron.

In the 10-light transformer, Foucault currents were very effectually weeded out by the interposition of sheets of paper between

* Abstract from a Paper read before the American Institute of Electrical Engineers, New York June 17, 1890.

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the laminated sheets of iron; in the 40-light the oxide of iron on the surface of the plates was the only safeguard against Foucault currents.

The form and extent of the open-circuit curves show the loss due to hysteresis and the slight loss also due to Foucault currents. The presence of Foucault currents is indicated by the fact that the maximum of the primary current wave does not occur simultaneously with the zero of primary E.M.F., but a little before. It is found upon analysis of the primary current curve into its elements, hysteresis and Foucault currents (*see* Fig. 2) that the Foucault current component occurs 120deg. in advance of the theoretical magnetisation curve, and not 90deg. in advance, as has generally been assumed. Therefore, when superimposed upon the hysteresis curve, it introduces a component in advance, and thereby decreases the lag of the primary current.

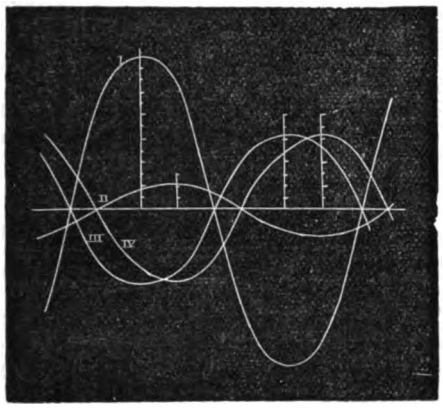

FIG. 3.—Small motor on secondary.

I. Primary E.M.F. [maximum 1,300 volts].
II. „ Current [maximum 0·55 amp.].
III. Secondary E.M.F. [maximum 63 volts].
IV. „ Current [maximum 8 amps.].

The lag of the primary current behind the primary E.M.F. is seen to be greatest when the secondary circuit was open, and decreases as a non-inductive load is introduced into the secondary circuit. This tendency of the lag of the primary current to decrease with increase of load continues until the curve of primary current comes into unison with the curve of secondary E.M.F.

The secondary E.M.F. is in unison with the primary E.M.F. on open circuit, and gradually falls behind as the load increases on the secondary. This is doubtless due to the leakage of lines of force arising from the enormous magnetising forces at work in opposition to one another in the primary and secondary ciruits.

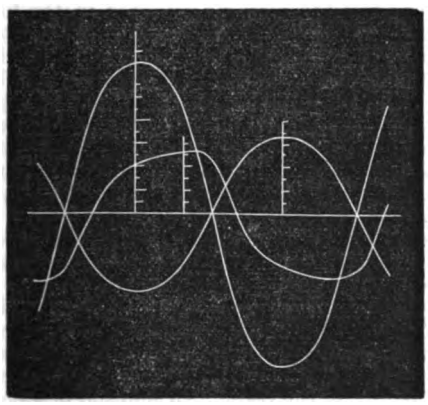

FIG. 4.

Inductive resistance in circuit of secondary.
Maximum primary volts, 1,300.
„ „ current, 0·13.
Secondary volts, 65.

When an inductive resistance is introduced into the secondary circuit, the lag of the primary current is greatly increased, as shown by the set of curves in Fig. 3. The inductive resistance used in this case was due to a small alternating-current motor. The curve of secondary current was also taken, and found to lag behind the secondary E.M.F., and to be in unison with the primary current. About 5·5 amperes flowed in the secondary, and yet the lag of primary current is as great as on open circuit.

Fig. 4 shows the relation of primary current and primary E.M.F. when the secondary was closed through the secondary of a 20-light transformer, whose primary remained open. The current curve shows a distinctive lag from the inductive resistance and is altered in form to a great extent.

The outside loop in Fig. 5 is the loop of total hysteresis loss and Foucault currents—deduced from the open circuit curves in the following manner: The current which flows to maintain the counter E.M.F. of the transformer on open circuit obviously includes the losses due to Foucault currents and hysteresis. If, thon, a magnetisation curve, whose maximum has been computed, be drawn in

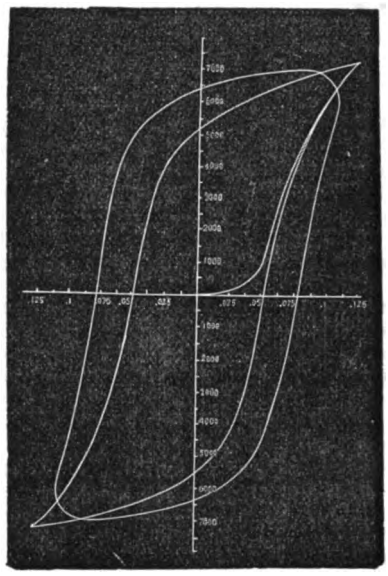

FIG. 5.

Ordinates, in lines of force per square centimetre.
Abscissæ, Amperes in primary.

90deg. behind the curve of primary E.M.F. and of the same form —since it is a function of the E.M.F.—and a curve be plotted using ordinates of primary current and abscissæ, and corresponding values of lines of force from the theoretical magnetisation curve, as ordinates, the outside loop in Fig. 5 is obtained.

The inside loop is the ordinary Ewing curve of hysteresis loss found by carrying the iron slowly through a complete cycle of magnetisation. The lines of force were computed from the *kick* on a ballistic galvanometer. This curve has in it no Foucault current effects. If, then, we reverse the above method, and from the Ewing curve and the magnetisation curve deduce a primary current curve, we shall have a curve representing hysteresis (for this iron) loss.

This was done; and it is of special interest to note that the form of curve obtained in this manner is identical with the open circuit curve of the 10-light transformer in which Foucault currents were suppressed by the interposition of sheets of paper (*see* curve III., Fig. 2). Having, then, two curves plotted to the same scale, one epresenting total loss and the other hysteresis loss, if we subtract rdinates of the latter from corresponding ordinates of the former,

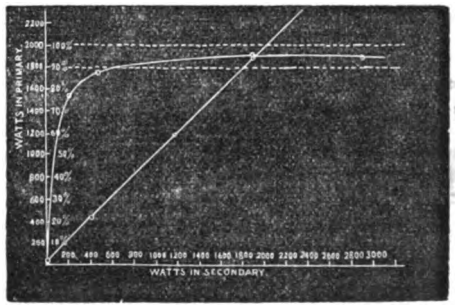

FIG. 6

a curve representing the component due to Foucault currents will be obtained (curve IV., Fig. 2). It was in this manner that the analysis before referred to was made. The position of the Foucault current component accounts for the round corners in the outside loop of Fig. 5.

The efficiency curve shown in Fig. 6 is the ratio between the energy of the primary circuit as indicated by the mean ordinate of the watt curve, and the energy of the secondary circuit as expressed

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by the product of the $\sqrt{\text{mean}^2}$ readings for E.M.F. and current. The coercive force is equal to 0·8 C.-G.-S.

These considerations go to show that the loss due to the reversal of polarity of the iron, which perhaps must always be present, may be reduced almost indefinitely by a proper study of the magnetic properties of the iron used.

THE ELECTRO-DEPOSITION OF PLATINUM.*

BY WM. H. WAHL.

(Concluded from page 262.)

Of the salts that may be formed from platinic hydrate by solution in acids (and in part by suitable combination with the corresponding alkaline compounds to form double salts), three only may be named as sufficiently useful to yield practically valuable results in plating. These are the phosphates, oxalates, and acetates, of which also it is practicable to form double salts with the alkalies, soda, potassa, and ammonia, which yield bright, reguline, and adherent plating.

Oxalic acid, so far as I have been able to determine, of all the oxygen acids, is the best solvent of platinic hydrate, dissolving it even in the cold, but with great energy when aided by heat, and forming platinous oxalate, with evolution of carbonic anhydride. From this brownish-black or deep blue solution (according to concentration), brilliant reddish-brown scales of the salt separate abundantly and readily from the hot saturated solution. A saturated aqueous solution of the simple oxalate prepared from the hydrate as above described, will yield bright, reguline, adherent platinum when electrolyzed with a comparatively weak current, with evolution of carbonic anhydride at the anode. With a stronger current hydrogen also appears at the cathode. This bath may be maintained indefinitely at normal metallic strength by observing the precaution to add oxalic acid and platinic hydrate in small quantities from time to time; or by keeping constantly at the bottom of the bath some platinic hydrate, and adding oxalic acid in crystals or powder from time to time as may be required to keep the bath saturated; or, what is much to be preferred, making a supply of platinous oxalate from platinic hydrate in the manner previously described, and keeping an excess of this present in the bath at all times. This bath has the same advantages as are possessed by the above-described alkaline platinate baths, of being capable of indefinite maintenance at normal metallic strength, and of introducing no substances that will cause its deterioration by the formation of secondary decomposition products.

Phosphoric acid also is a solvent of platinic hydrate. A dilute aqueous solution of this acid will dissolve a small quantity of the metallic hydrate in the cold, and a much larger quantity when aided by heat. With increasing concentration, the solvent power of this acid for platinic hydrate is correspondingly increased. The resulting solution of phosphate of platinum, according to the degree of concentration, will be wine-yellow to cherry-red in colour, and with a comparatively weak current, will yield bright, reguline and adherent platinum on metallic surfaces properly prepared to accept the same. The electrolysis of this compound also does not involve the formation of deleterious secondary products, the result of the operation being the separation of the metal at the cathode and of the acid radical at the anode—and of the elements of water which are evolved as gases respectively from anode and cathode. In the operation of the bath, therefore, it will become more and more acid as the metal is withdrawn by the accumulation therein of the phosphoric acid set free at the anode. The maintenance of the metallic strength of the bath, therefore, may be effected as in the foregoing cases by having present therein at all times a small quantity of platinic hydrate or by the addition at the end of each day's work of the quantity of the metallic hydrate which will be required to restore the amount of metal withdrawn. This bath must be worked very acid, and the solution of the platinic hydrate to maintain the strength of the bath must be facilitated by heating, as the solvent power of phosphoric acid for platinic hydrate is much inferior to that of oxalic acid. The double phosphates of platinum with certain of the alkalies may be formed, which will be capable of yielding a deposit of bright, reguline and adherent metal, and of being maintained approximately at normal metallic strength in the same manner as I have set forth above. The best results I have obtained with the ammonio-platinic phosphate, prepared by adding to the solution of platinic hydrate in phosphoric acid sufficient aqua ammoniæ to cause the same to give an alkaline reaction, which point will be indicated by the formation of a greyish precipitate that will not disappear on stirring; then restoring the acidity of the solution by adding free phosphoric acid in excess, upon which the precipitate readily dissolves. The resulting solution is yellowish or brownish, and yields superb plating; though, on account of the greater difficulty of maintaining its metallic strength by the solution of the hydroxide, it is not so well adapted as the oxalate for the work of electro-deposition on the large scale. The sodio-platinic phosphate formed in a manner precisely analogous to the ammonia compound just described, will also yield bright, reguline, and adherent plating; but I have observed that the soda salt is less freely soluble than the corresponding ammonia compound, and consequently more difficult than the latter to maintain of normal metallic strength.

The presence of acetic acid in an alkaline bath appears favourably to influence the quality of the plating yielded, giving the deposited metal a whiteness approaching that of silver; and furthermore, acetic acid yields only the elements of water and volatile compounds, when electrolised and therefore does not contaminate the electrolytic bath by forming deleterious secondary products.

The foregoing comprise the compounds that I have found to yield the most satisfactory results in platinum plating. I append directions for the preparation of the several electrolytic baths above described, and indicate what I have found to be the most favourable conditions for working them.

Directions for Preparing the Electro-Plating Baths.—For the alkaline platinate bath, the following directions may suffice:—

Platinic hydrate	2oz.
Caustic potassa (of soda)	8oz.
Distilled water	1gallon

Dissolve one-half of the caustic potassa in a quart of distilled water; add to this the platinic hydrate in small quantity at a time, facilitating solution by stirring with a glass rod. When solution is effected, stir in the other half of alkali dissolved in a quart of water; then dilute with enough distilled water to form one gallon of solution. To hasten solution, the caustic alkali may be gently heated; but this is not necessary, as the platinic hydrate dissolves very freely. This solution should be worked with a current about two volts and will yield metal of an almost silvery whiteness upon polished surfaces of copper and brass, and quite freely. There should be slight, if any, perceptible evolution of hydrogen at the cathode, but a liberal evolution of oxygen at the anode. I have observed that the addition of a small proportion of acetic acid to this bath improves its operation where a heavy deposit is desired. The anode may be of platinum or carbon, and owing to the readiness with which the metal is deposited an excess of anode surface is to be avoided. Articles of steel, nickel, tin, zinc, or german-silver, will be coated with black and more or less non-adherent platinum; but by giving objects of these metals a preliminary thin electro-deposit of copper in the hot cyanide bath, they may be electro-platinised in the alkaline platinate bath equally as well as copper. The bath may be worked hot or cold, but it is recommended to work it at a temperature not exceeding 100°F. It may be diluted to one-half the strength indicated in the formula, and still yield excellent results. The surface of the objects should be highly polished by buffing, or otherwise, prior to their introduction in the bath, if the resulting deposit is designed to be brilliant.

The deposition of platinum takes place promptly. In five minutes, a sufficiently heavy coating will be obtained for most purposes. The deposited metal is so soft, however, that it requires to be buffed very lightly. A heavier deposit will appear grey in colour, but will accept the characteristic lustre of platinum beneath the burnisher.

The oxalate solution is prepared by dissolving one ounce of platinic hydrate in four ounces of oxalic acid and diluting the solution to the volume of one gallon with distilled water. The solution should be kept acidified by the occasional addition of some oxalic acid. The simplest plan of using this bath, and which requires no attention to proportions, is simply to work with a saturated solution of the oxalate, keeping an undissolved excess always present at the bottom of the vessel. An addition of a small quantity of oxalic acid now and again will be found advantageous. The double salts of oxalic acid with platinum and the alkalies may be formed by saturating the oxalate of the desired alkali with platinic hydrate and maintaining the bath in normal metallic strength by the presence of an undissolved residuum of platinous oxalate.

The double oxalates are not so soluble in water as the simple salt. The oxalate baths, both of single and double salts, may be worked cold or hot (though not to exceed 150°F.), with a current of comparatively low pressure. The metal will deposit bright, reguline and adherent on copper and brass. Other metallic objects must receive a preliminary coppering as above. The deposited metal is dense, with a steely appearance, and can be obtained of any desired thickness.

The deposit obtained in the oxalate baths is sensibly harder than that from the alkaline platinate bath, and will bear buffing tolerably well.

* Read at the meeting of the Chemical Section of the Franklin Institute Philadelphia, May 20, 1890.

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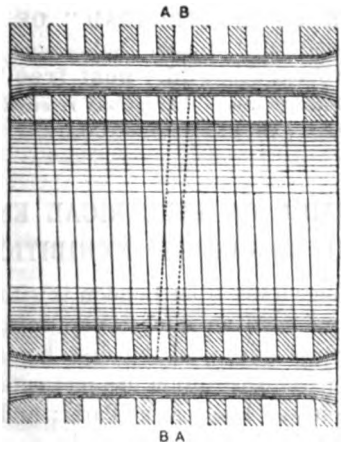
The phosphate bath may be prepared by the following formula:—

Phosphoric acid, syrupy (sp. gr. 1·7)	8oz.
Platinic hydrate	1—1½oz.
Distilled water	1 gallon.

The acid should be moderately diluted with distilled water, and the solution of the hydrate effected at the boiling temperature. Water should be added cautiously from time to time to supply that lost by evaporation. When solution has taken place, the same should be diluted with sufficient water to make the volume one gallon. The solution may be worked cold or warm to 100°F., and with a current much stronger than that required for the platinates and oxalates. The ammonio- (and sodio-) platinic phosphates may be formed from the simple phosphate by carefully neutralising the solution of the phosphate with ammonia (or soda); then adding an excess of phosphoric acid, or enough to dissolve the precipitate formed and an additional quantity to ensure a moderate amount of free phosphoric acid in the bath. The phosphate baths will be maintained of normal strength by additions of platinic hydrate, the solutions of which will have to be assisted by heating the bath, preferably at the close of each day's work. The metal yielded by the electrolysis of these phosphate solutions is brilliant and adherent. It has the same steely appearance as that exhibited by the oxalate solutions, but to a less pronounced degree. The physical properties of the deposited metal are in other respects like those described in connection with that obatined from the oxalate baths.

CHAMBERLAIN'S COMPOSITE "WAVE" PINION FOR ELECTRIC CARS.*

The high speed at which electric motors are required to operate in order to secure a proper efficiency has necessitated the employment of gearing to reduce the speed of the armature shaft to that of the car axles. The noise and vibration accompanying the employment of solid gear-wheels, however, soon became apparent, and means for overcoming both were applied, which consisted in the substitution of pinions built up of alternate layers or discs of steel and a variety of substances, such as raw hide, fibre, &c. These composite pinions, it is true, largely reduced the troubles formerly



experienced, but they introduced others which those operating electric railways have found to be of considerable moment. These consist principally in the fact that, owing to the layers of the composite pinion being placed in planes at right angles to the axis of the shaft, the wear on the all-metal gear-wheel is confined almost wholly to the parts opposite. The result of this is that circumferential grooves are worn in the all-metal gear, which leave ridges at the parts opposite the rawhide. The wear being thus confined to a portion only of the all-metal wheel, the same is more rapidly worn away and its working life is considerably shorter than would be the case were the wear equally distributed.

While the non-resonant qualities of the composite gear were highly desirable, it was manifest that an improvement designed to afford an even wear of both pinion and gear was of not less importance; and this has been effected in a very simple and ingenious manner by Mr. Jacob C. Chamberlain, of this city.

The desired object has been accomplished by placing the alternate layers of metal and rawhide of which the pinion is composed at a slight angle or cant to the axis of the wheel, so that the metal portions in bearing on the all-metal wheel travel laterally upon the same in a worm-like or "wave" motion, so as to distribute the wear.

The construction of a pinion built up in this manner will be readily understood by an examination of the sectional drawing shown in the figure. Here it will be noted the steel disc occupies the position A A at one point; during the next half-revolution, however, on account of its slant, it will have assumed the position shown in the dotted lines B B. The result of this is that each tooth of a disc bears in part on a portion of the engaging wheel different from that engaged by the preceding tooth, thus shifting the wear and distributing it over the whole working face of the all-metal wheel. To fully accomplish this result, it is necessary to give a lateral displacement between opposite diameters of the discs equal to the thickness of the rawhide discs. It is also necessary that the number of teeth on the composite pinion should not be exactly divisible into the number of teeth on the all-metal wheel, and it is desirable that the numbers of teeth should be prime to, or incommensurable with one another, so that each tooth on the pinion shall be brought into engagement with each tooth on the gear-wheel. To prevent the rawhide discs from slipping when clamped between the metal discs, the end faces of the latter are provided with projections, struck up out of the surface of the discs like the teeth of a file, and these grip the rawhide securely. The actual results are excellent.

* From the *Electrical Engineer* of New York.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS.—MONDAY, July 14th.

Central London Railway Bill.

The Select Committee of the House of Lords on this Bill resumed their inquiry on Monday, under the presidency of Lord Henley. Among the witnesses called was Mr. Henry Gotto, of the firm of Parkins and Gotto, Oxford-street. He was of opinion that there was no congestion of the traffic in Oxford-street, except at Tottenham Court-road and Oxford-circus, and he had noticed that the traffic was considerably less since Shaftesbury-avenue had been opened. He expressed the opinion that the carting of material during the construction of the line would cause injury to business.

Mr. MARSHALL (of the firm of Marshall and Snelgrove) was next examined. He was of opinion that the cartage of material would cause damage to the rateable value of property. He did not object to an electric railway, but wanted it tried somewhere else.

Mr. JEUNE, Q.C., appearing for the Ecclesiastical Commissioners and St. Paul's Cathedral, then addressed the Committee, and called evidence in support of his case, and the Committee adjourned.

TUESDAY, July 15th.

On the further consideration of this Bill, Mr. PENROSE, architect to St. Paul's Cathedral, was cross-examined by Mr. Pember. He believed the clay under St. Paul's was at a great depth, and over it, according to Sir Christopher Wren, was water-bearing sand, which he thought would tend to run in the direction of the proposed line. If the promoters made use of this power of deviation they ought to keep in the solid London clay, under which circumstances he did not see any objection. The removal of water might cause a subsidence under St. Paul's, and if the clay happened to be rotten there was danger of its slipping.

Mr. EDWARD BOURNE LEWIS, C.E., said that, in his opinion, were the clay to begin slipping, as was frequently the case, it was quite possible that it might interfere with the foundation of St. Paul's, and so cause injury to that building. He mentioned that injury had happened to the premises of the National Safe Deposit Company in the Poultry through the slipping of the clay, notwithstanding the fact that it had a foundation of 6ft., and in some places 15ft., of concrete. He was strongly of opinion that the construction of a station in the vicinity of St. Paul's was a risk that ought not to be run.

Sir ALEXANDER RENDEL supported the evidence of the other engineers called in opposition to the scheme.

The Committee adjourned.

WEDNESDAY, JULY 17th.

On Wednesday the Committee engaged in considering this Bill concluded its proceedings.

Mr. LITTLER, Q.C., proceeded to addressed the Committee on behalf of the Metropolitan Railway Company, and of frontagers in Paddington. It was proposed, he said, to adopt an entirely new system of working which had not turned out to be an unqualified success on the City of London and Southwark Subway. By passing the Bill the Committee would be doing an injury by preventing the proper solution of this question, namely, the construction of a new street parallel with Oxford-street. Having regard to all the circumstances which had been laid before their lordships, he asked them to say that the Bill should not be allowed to proceed further.

At the conclusion of Mr. Pember's speech for the promoters the room was cleared.

After the Committee had deliberated in private for about a quarter of an hour, counsel and parties were called in.

The CHAIRMAN, in announcing the decision of the Committee, said—The Committee have given very careful consideration to the evidence which has been laid before them, and we have come to the conclusion that the preamble of the Bill is not proved.

The inquiry then terminated.

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THE INSTITUTION OF ELECTRICAL ENGINEERS AT THE EDINBURGH EXHIBITION.

To hold meetings away from London is with the Institution of Electrical Engineers an almost new departure. We say almost new, because this is not the first, but the second time in its history that the Institution has met outside its domicile. The first occasion was last year at Paris; and the success of that meeting was the best proof that the new departure has been a step in the right direction. It is only surprising that the Institution should not have begun much sooner than it did to vary their place of meeting according to circumstances. This policy has been pursued for years past by a kindred society, viz., the Institution of Mechanical Engineers, and has greatly contributed to the practical value of the work done by that body. If during the last ten years the Institute of Electrical Engineers had held meetings at the more prominent Electrical Exhibitions, such as Paris, Munich, Vienna, Philadelphia and London, we should now be able to find in its "Journal" authentic records of the conditions of applied electrical science at the various dates; and such information, apart from purely historic interest, would have been of great practical value. The opportunity has not been taken advantage of until last year; but now that a beginning has been made it is to be hoped that the Institute, as a body, will continue the policy which has found practical illustration at their extraordinary general meeting in Edinburgh.

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That this meeting was on the whole a great success is admitted on all hands, and in point of numbers it exceeded that of last year held in Paris. The idea of inviting the Institution of Electrical Engineers to visit the Edinburgh Exhibition as a body originated, we believe, with Mr. A. R. BENNETT, the Vice-Chairman of the Executive Council of the Exhibition, and was taken up by the other members of the Council who have co-operated with Mr. BENNETT in this matter. The programme elaborated by these gentlemen was both instructive and entertaining, the entertaining part, however, predominating; which is as it should be. Electrical engineers, like other professional men, are not over-much fond of hard work towards the end of summer, when thoughts of a holiday and rest begin to assume tangible shape; and therefore it is well to dilute a moderate amount of instruction with a rather large dose of pleasure; and that is what has been done at the Edinburgh meeting. We had there, Papers and inspections of exhibits for work; and a *conversazione*, excursions to the Forth Bridge and on the Union Canal for play,

As regards the Papers, we have already commented upon the first Paper, read by Dr. WALMSLEY, in another column, and need therefore not refer to it at greater length in this place than to say that it was just the kind of Paper wanted on such an occasion. The Paper by Prof. AYRTON and Messrs. LAMB, SMITH, and WOODS, on "The Working Efficiency of Secondary Cells," which was read on Wednesday morning, was, however, of too deeply scientific a character for an assembly in holiday mood, and did not receive an adequate discussion. The authors have done an enormous amount of experimental work by means of specially constructed apparatus, and have given in their Paper the results obtained in a condensed form convenient for reference. A Paper of this kind cannot be thoroughly appreciated except after a very exhaustive discussion; and, in the absence of several of the foremost men who have done practical work in storage batteries, the discussion could not possibly be of that character. Some of the results arrived at by the authors are of great practical importance. They find, for instance, that charge and discharge tests of storage batteries may be extremely misleading. If such batteries be thoroughly well charged up before being tested they contain a large store of energy, which can only be drawn out in repeated discharges; and consequently the efficiency tests of the first few charges and discharges give results which are too high. The general conclusion arrived at by the authors as regards efficiency is, however, very encouraging. They find that in steady work with maximum charging and discharging currents the quantity efficiency reaches 97 and the energy efficiency 87 per cent., results decidedly better than most electricians believe to be possible.

On Tuesday afternoon the members of the Institution were conducted through the Exhibition by Dr. WALMSLEY and Mr. BENNETT. Personally conducted tours of this kind have many advantages. In the first place a great deal of time is saved by not having to look at exhibits which may, after prolonged inspection, turn out to be hardly worth that trouble, and in the second place, the attendance of exhibitors is thereby ensured. In the present case several of the more important exhibitors had either come specially to Edinburgh to be personally in attendance at their stalls when the members of the Institute came to visit them, or they had sent representatives capable of giving intelligible explanations of the exhibit —a quality not always possessed by the usual run of attendants at Exhibitions. As a rule, the person in charge of a stall knows very little about the construction and working of the machinery under his care, and the little he knows he thinks he must keep from the visitor, whose inquisitiveness is not always viewed with favour. Under such circumstances the amount of mental labour required to elicit trustworthy information is sometimes very considerable. The inquiring visitor must adapt his questions to the intellectual capacity of the man in charge, and arrive by a slow process of cross-examination at information which the less suspicious but more intelligent exhibitor or attendant could have conveyed in a few words. In this respect also the members going round in a body had the advantage over the scientific tourist struggling on by himself alone.

The Exhibition is nominally an international one, but France is the only foreign country represented in the Electrical Section; and we may at once say that the representation does not do justice to French electrical engineering. Not only are the exhibits in themselves below the average in interest, but they are not properly shown. In the British Section the most striking feature is, perhaps, the very liberal way in which the Executive Council have provided space for the lighting machinery. In most previous Exhibitions the dynamos and engines for lighting were stowed away into odd spaces, and as much as possible out of sight; whereas in Edinburgh they form the principal exhibits, occupying the middle of the Machinery Hall. Another feature which could not fail to be noted by the members of the Institution as they went from stand to stand is the small extent to which the large electrical engineering firms in the South and centre of England are represented. The Exhibition is in fact principally illustrative of the work done in the North of England and in Scotland, and as such it is an admirably complete and representative show.

There is one more feature of the meeting of Electrical Engineers at Edinburgh to which we must refer; and that is the great cordiality with which the London and English members generally were received, not only by their professional brethren north of the Tweed, but by all those gentlemen who took part in organising the reception. This feeling found expression, not only in the official way by speeches and ceremonies usual on such occasions, but also in the very tangible form of an offer on the part of several prominent citizens to become the hosts to any of the members who should like to accept their hospitality during their stay in Edinburgh. We do not know to what extent, if at all, the members have availed themselves of this very liberal offer of hospitality; but the very fact that the offer was unreservedly made is a testimony of the very cordial feeling which exists between the people of Edinburgh and their scientific visitors.

THE NATIONAL TELEPHONE COMPANY.

Whatever may be thought of the future prospects of the NATIONAL TELEPHONE COMPANY, its present position, as set forth at the annual meeting last Friday, is highly satisfactory. With a dividend of six per cent., an increase in the gross revenue, a decrease in the working expenses, and a large addition to the reserve fund, the shareholders may well be content to take the good things as they come, and not inquire too curiously into the evils that may shortly be in store for them. Nor can it be said that their confidence in the present directorate has been misplaced so far. The policy of amalgamation has been steadily pursued until only two companies remain outside the National Company's system, and these will probably fall in before the next annual meeting. Similarly, the extension of the trunk lines has been courageously carried out with the object of covering the ground

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and creating what the chairman called "a great stand-by in regard to competition," notwithstanding the problematical character of the profits to be derived from them. In view of possible acquisition by the State, both these projects were of doubtful expediency; but as events have turned out, the amalgamations and the trunk lines are probably the best methods that could have been devised to meet the alternative of open competition when the patent rights shall have expired. The Government having waived its right of compulsory purchase for another seven years, these precautionary measures were the only ones remaining to the companies under the circumstances.

A large portion of the Chairman's speech was devoted to the. perhaps, needless task of proving that the charges of the British Telephone Companies are not excessive when compared with those of other countries where the conditions are the same. A dividend of six per cent. is not an extravagant one; and this of itself, supposing the working expenses are not extravagant, is proof that the price demanded by the National Telephone Company for the service it renders is not unreasonably high. With the exception of Sweden and Norway, where the local conditions are peculiarly favourable to the undertakers, the charges in other European countries do not materially differ from those which obtain in this country, when allowance is made for the lines being Government property, and exempt from the royalties which British proprietors have to pay. Ten per cent. of gross revenue, on the other hand, is not an exorbitant price to pay for the privilege of pocketing six per cent. net; and it is too often forgotten that the privilege was the result of a bargain, which, had it been rejected by the Telephone Companies, would have ended their existence altogether many years ago. The price that is paid for that privilege—a very valuable one—goes into the national exchequer; and this fact has to be taken into account as a set-off, when complaints against the Company's charges assume national dimensions. But we take it that although those charges are relatively high, they are not resented so much by those who pay them as by those who are debarred from using the telephone, or by those social philosophers who argue that the popularisation of the telephone system, like the popularisation of the postal system, would work miracles for the material welfare of the people.

In this relation we may mention an interesting article which appeared in the *Nottingham Express* of 30th ult., where it was confidently argued that if the telephone were made possible of extension to every village and every market town —or, at all events, to all the outlying suburbs of large manufacturing towns—the decay of the rural districts would be arrested, and the migration of rural populations into congested centres of industry would cease. The grounds for this belief are to be found in the fact that local industry on a small scale is impossible in these days without swift means of communication with the larger centres of trade and commerce; and that a cheap and widely extended telephone system would undoubtedly supply what is needed. There are, no doubt, other causes operating to bring about the gradual extinction of suburban and rural manufactures; but it may be admitted that the one alluded to has a considerable share in the result. It is, at all events, a fresh and powerful argument in favour of the telephone service being made as popular as possible; and, of course, the propounder of this idea very much deplored the refusal of the Government to buy up the telephone interests at once. There is little doubt that this regret is widely felt; and that its acquisition by the State, with consequent popularisation of the telephone system, would have been a very welcome announcement to the community at large. Probably the chief objectors were the people at the Treasury Office, who are too much occupied at present with other schemes involving great expenditure, to entertain the idea of adding one more to the costly and gigantic businesses which the State has taken in hand.

A popular system of telephony seems, therefore, as far off as ever, for we cannot expect much in that direction from the competition with which the National Company is threatened when its patents expire. Of possible competition on the part of the Post Office the Chairman said nothing, although he was elaborate in his proofs that a projected competing company at Manchester would meet with insurmountable difficulties in its career. For our part we cannot help thinking that one of its first and chiefest difficulties will be to obtain the licence of the Postmaster-General. To grant licences to one or two competing companies would do little good, and to grant them indiscriminately would lead to nothing better than confusion all round, and render the ultimate transfer to State control more difficult than it is at present. A judicious but merciful rivalry, gradually introduced by the Post Office itself, is much to be preferred, restraining as it would do the projects of existing companies within reasonable limits, and establishing a standard of excellence and cost which the public would then have a right to expect of the Government's licensees. The significant hints he has let fall as to the impending extinction of the telephone patents indicate that Mr. RAIKES is quite alive to any advantage he may take of the changed situation which that event will bring about. Whatever may be thought of the cynical language he has employed towards them, it cannot be said that he has left the companies unwarned. His utterances indeed have been so candid that the public will require of him some corresponding action when the time for action arrives. At present they can only hope that it may be for the best interest of the public, who have a right to expect that whatever good the telephone can do, shall be done speedily, with or without the Postmaster-General's interposition.

THE EDINBURGH MEETING OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

Tuesday, July 15th.

A three days' meeting of the Institution of Electrical Engineers commenced in Edinburgh on Tuesday last, the sittings being held in the Phonograph Room of the International Exhibition. About a hundred and forty members were present at the proceedings on Tuesday morning.

The PRESIDENT, in opening the meeting, expressed his satisfaction that so many members of the Institute had come to Edinburgh to enjoy the hospitality which had been so generously extended to them, to have a look round the Exhibition, which appeared to him to be of considerable magnitude and importance, to be present at the *conversazione* which was to be held that evening, and to attend the excursions that had been arranged for the visit.

The SECRETARY intimated that Sir Archibald Campbell, Bart., of Blytheswood, had sent an invitation to the Institution to visit his private workshop, in which there were many things of interest to electricians.

Papers were then read on "Some Features, mainly Electrical, of the Edinburgh Exhibition," by Dr. R. Mullineux Walmsley, and on "Foreign Currents in Telegraph and Telephone Lines," by Mr. A. R. Bennett.

In the evening the Executive Council of the Exhibition entertained the members of the Institution and a number of other guests at a *conversazione* in the Grand Hall. The company, numbering four or five hundred ladies and gentlemen, were received by Sir Thomas Clark, Chairman of the Executive,

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Councillor Kinloch Anderson, Mr. A. R. Bennett, manager of the National Telephone Company of Scotland, and other members of the Executive.

Sir THOMAS CLARK having welcomed the members of the Institution to the Exhibition, Lord KINGSBURGH briefly addressed the company as a member of the Institution. Among the numerous objects of interest were phonographs, high-speed Wheatstone instruments working with Glasgow, and a line by Peterhead to Norway, by which, during the evening, Sir Thomas Clark offered the salutations of the Council to the King of Sweden, at Stockholm. The National Telephone Company had provided communication to Galashiels (40 miles) and Dundee (109 miles). Mr. Bennett exhibited some interesting radioscopes. Dr. Milne Murray showed a galvanometer for physiological purposes.

Wednesday, July 16th.

On Wednesday the meeting of the Institution was resumed in the lecture room of the Exhibition, Mr. W. H. Preece in the chair; and a Paper by Prof. W. E. Ayrton and Messrs. C. G. Lamb, E. W. Smith, and M. W. Woods, on "The Working Efficiency of Secondary Cells," was read by Mr. Lamb.

"Some of the chief Features of the Exhibition, and mainly of the Electrical Section."*

BY DR. R. MULLINEUX WALMSLEY.

After touching on the historical aspect of some of the principal exhibits, Dr. Walmsley took up the subject of telegraphy. In the modern part of an Electrical Exhibition, telegraphy, he said, naturally claimed the first place, both on account of seniority and importance. On the Post Office stand the various modern instruments now used were shown. Special interest attached to the complete set of Wheatstone fast-speed instruments, including the transmitter, the Intermediate Station or Repeater, and the receiver. There was also the ingenious Delaney distributor, by means of which six signallers could use the same line at once, or, to speak more correctly, each of the signallers in turn had the line to himself for certain fractions of each second, which follow one another so rapidly that by use of a suitable receiver at the far end the message was practically continuous. The instrument, which was of American origin, was not much used in this country, being, he was informed, only employed at present between London and Brighton, and Manchester and Liverpool. In the French Court there would be found several Baudot distributors which preceded that of Delaney in point of time, and used the same principle of two arms rotating synchronously over two discs, one at either end of the line. Of the instruments exhibited, some enabled four, others enabled six signallers to use the line.

The Eastern Telegraph Company exhibited a self-starting Morse-writer, in which the clockwork was superseded by an electro-magnetic arrangement which drove the paper by means of a pawl engaging with a toothed wheel. In connection with the exhibit of the Eastern Telegraph Company, he pointed out the electrical identity between the syphon recorder, "No. 300," and the so-called D'Arsonval galvanometer. As a matter of justice, the latter should be called either a "Thomson" galvanometer, because of the syphon recorder, or a "Maxwell" galvanometer, since its essential part figured in Clerk-Maxwell's classical book. The obvious objection of the former name was that Sir William had produced so many types of excellent current measuring instruments that the term "Thomson galvanometer" had almost ceased to have a distinct or specifying meaning. He might mention, as connected with modern telegraphy, an ingenious improvement of the Pneumatic Transmitter, exhibited by Mr. William Blakeney, of Glasgow, and called a Duplex Automatic Transmitter. The attendant had merely to place his carrier in a receptacle of the tube, and as soon as the tube was clear it would be forwarded. No complicated system of levers had to be worked, nor had any signal to be sent between the attendants at the two ends. That was accomplished by means of electro-magnets and a simple reversing key.

Dealing with electric lighting, he said the actual lighting of the Exhibition did not offer any particularly novel feature. The arc lighting was in charge of the Brush Electrical Engineering Company, who used their well-known double carbon 10-ampere lamps. The bulk of the glow lighting had been carried out by King, Brown, and Co. The only purely American lighting exhibit was a 30-arc light dynamo, together with 30 arc lamps of the Western Electric Company, of Chicago. Visitors would, he thought, be interested if they would compare various details connected with that machine with English built machines. The lamp was a well-made and simple clutch lamp. Perhaps the only point about its mechanism was the very small amount of travel and the strong pull required on the armature of the series magnet to strike the arc. It was fed with a current of 18 amperes at 30 volts; in other words, the arc was deliberately intended to hiss, a method which would scarcely find favour on this side of the ocean.

With regard to prime movers, he drew attention to the vertical Compound engine exhibited by the Brush Company. Special engines for electric light work were exhibited by Mr. David Carlaw, of Glasgow, and Messrs. J. F. Blyth and Co., who manufacture the "Newall" engine (see *Electrician*, December 27, p. 196). All the well-known gas engine makers were represented. With the amount of water power that was available in Scotland it was surprising that so few water motors were exhibited. A good collection of "Waverley" turbines was shown by Messrs. Carrick and Ritchie. The sizes ranged from 2·7 to 105 horse-power for falls varying from five to 80 feet, and a large proportion of the available energy was given out on the shaft. In regard to the transmission of power, he pointed out that the electric launches plying on the canal only differed from those used on the Thames in one or two unimportant details. The other chief working examples of the electric transmission of power were the Telpher line and the Electric railway.

The telephone exhibits did not offer many striking novelties for comment. The visitor could, within a small compass, compare the instruments produced under the close monopoly which prevailed in this country with those which were the outcome of the competition between the various French firms. An ingenious automatic switch-board, with transmitter, receiver, &c., was shown by the Consolidated Telephone Construction Company (see *Electrician*, Feb. 14, p. 370). It should be of great service to hotels, works, warehouses, &c., which required the use of several telephones without the expense of an exchange installation. The National Telephone Company also displayed a few exhibits, amongst which was a Bennett's telephonic transformer or translator. This exhibit was very interesting from the fact that a closed magnetic circuit was used, and was found in practice to be better than an open circuit; it could be used both to ring up and to talk through, whereas, the older forms were not applicable to both purposes. As regarded long-distance telephones, some of the visitors might be interested to hear that they could talk through from the Exhibition to Aberdeen, a distance of 200 miles, also to Hawick in the south, and to Glasgow, Ayr and Greenock in the west. In fact, the network of trunk lines for central Scotland was fairly complete.

Although he had not room in his Paper to refer to the various purposes for which electric signalling was employed as distinct from the interchange of correspondence or telegraphy, he informed those interested in that important branch of electrical development that they would find in the Exhibition good exhibits of the most recent devices in actual operation. He might, perhaps, specially direct attention to the exhibits of the London and North-Western Railway Company, the Eastern Telegraph Company, Messrs. Woodhouse and Rawson, and Messrs. Cox-Walker and Co.

DISCUSSION.

The CHAIRMAN, having proposed a vote of thanks to Dr. Walmsley for his interesting Paper,

Mr. A. R. BENNETT said he was sure that after the description Dr. Walmsley had given of the electric tramway, it would be heard with a feeling of regret that that tramway was not yet open. The author had referred to "Bennett's translator," upon which he wished to make a remark. The original translator was his own, but the improvement which consisted in the close magnetic circuit was not his. It was a great improvement, but he was not aware who was responsible for it. With these, subscribers could ring through from one end to another.

Mr. W. H. PREECE expressed the thanks of the Council to Dr. Walmsley for his Paper. He should like to supply the Doctor with the accurate number of circuits of Delaney's multiplex apparatus. He could not make out more than sixteen circuits from memory; but he was very proud to know that these sixteen circuits were at work. This was an apparatus he saw at an exhibition such as this in 1884 in Philadelphia. It did not there attract much attention, but he saw it contained immense merit, great novelty, and solved in particular the problem of multiplex telegraphy. He induced Delaney to bring it over to the Inventions Exhibition for the next year. They tried it in the Post Office and found it work well. It was really now a practical instrument, and they had not used it yet in America.

Mr. C. E. SPAGNOLETTI said he wanted to add a few remarks to Dr. Walmsley's description of the long-distance telephones because he had an opportunity of being introduced to the gentleman who brought over the long-distance telephone. They tried some experiments with this instrument and made a communication with Reading on the Great Western Railway to Weymouth by one route and back another, a distance of about 470 miles, and they heard very well indeed. The Telephone Company then thought they would try the Bell telephone against this, and the result was that it was almost better than with the long-distance instrument. They tried it again from Victoria Station to Dover, communicating between two rooms in the station which was a distance of 300 miles. The conversation was heard very distinctly. He thought Mr. Preece had told them this

* Abstract of Paper read at the Extraordinary General Meeting of the Institution of Electrical Engineers, Edinburgh, 1890.

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had been beaten, because by a cable they had succeeded in communicating a distance of 1,000 miles.

Mr. PREECE said he had been wondering how, why, or where Mr. Spagnoletti had derived information from him that it was possible to speak through a thousand miles of cable; but he remembered it had been announced that they had spoken through a thousand miles of cable coiled in tanks at Henley's Works. There was a new telephone being shown that was said to speak through a thousand miles of cable, and there was no doubt if one put himself at each end of the cable, it did speak beautifully. But when he suggested that a telephone should be put half way nothing would be heard. It was, as Mr. Bennett had said, merely an electrostatic action at the ends of the wire. This was a fallacy that had been very often repeated, and he was sorry to say he had been compelled to arrange for experiments along two actual cables in the North Sea, from Holland to England, in order to convince certain gentlemen that it was impossible to speak through such a long distance. It was perfectly easy to speak a thousand miles or more on overhead wires, and it was just as easy to construct a line of two wires to speak between London and Edinburgh as between Edinburgh and Glasgow.

Dr. WALMSLEY returned thanks, and expressed on behalf of himself and Mr. Bennett their readiness to undertake the guidance of the party through the Exhibition.

THE WORKING EFFICIENCY OF SECONDARY CELLS.*

By W. E. AYRTON, C. G. LAMB, E. W. SMITH, and M. W. WOODS, Associates.

1.—*Previous Tests of Cells.*

Since 1881, when the formation of Planté storage cells was greatly accelerated by Faure's device of pasting the plates, numerous tests have been made in different parts of the world on the capacity and efficiency of secondary cells. The first tests that were carried out were conducted simultaneously, at the end of 1881, in England by Prof. Perry, with one of the authors of this paper, and in France by a committee consisting of Messieurs Tresca, Potier, Joubert, and Allard, working at the Conservatoire des Arts at Metiers, with a staff of assistants.

In the report—communicated to the Physical Society in February, 1882—by the two English experimenters, it was pointed out that the great "resuscitating power" of the cells made it very difficult to say when they were entirely discharged, and therefore, in order to test the efficiency, the cells were first "emptied" of charge by discharging them until the discharge current was very small, and finally leaving them short-circuited for many hours with a short bit of thick wire. Next, a measured amount of energy was put into these "empty" cells, and they were then thoroughly discharged on three successive days, being insulated and allowed to recuperate during the two intervening nights. Although the energy efficiency thus obtained, and which was not less than 82 per cent., probably represented much more than could be obtained in practice at that period, if the discharge were stopped before the E.M.F. fell to so low a value, this efficiency represented something quite definite, since all the energy given out by the cells in the discharge must have been put into them during the measured charge, no demand being made on some inexhausted store of energy previously put into the cells.

The French Committee, on the other hand, considered the cells as being discharged when a certain current which was originally produced through a fixed resistance by 30 cells could no longer be kept up, even when the number of cells had been increased to 35. But unless, subsequently to the receipt of the cells from the manufacturers, they had been charged and discharged several times until the same cycles of values of E.M.F. with time were repeated with each charge and discharge, there was no guarantee that in the experimental discharge the cells were not drawing on a store of energy put into them before leaving the manufacturers' premises, and thus giving a higher value than the "working efficiency."

And we are afraid that a very possible neglect of the powerful resuscitating power of accumulators may have vitiated some of the published results of experiments that have been made on them. This doubt must not be forgotten in considering the list on opposite page, which is as complete as we have been able to make it, of all such experiments that have been made up to date. At the middle of 1889, when we had nearly completed our investigation, there appeared two very important contributions to the subject—one on "The Inherent Defects of Secondary Batteries," by Dr. Louis Duncan and H. Wiegand; the other, "Ergebnisse von Versuchen an Akkumulatoren für Stationsbetrieb" by Professor W. Kohlrausch and C. Heim. These investigations are extremely interesting, as they confirm some of the results which we had also arrived at, and to which reference will be made in this Paper;

* Read at the Extraordinary General Meeting of the Institution of Electrical Engineers at Edinburgh, on July 16th, 1890.

Professor W. Kohlrausch and C. Heim, for example, laying great stress on the fact that the discharge of an accumulator does not depend merely on the previous charge, but on the previous history of the cell.

At the Central Institution there are three distinct types of E.P.S. cells in daily use. The cells, however, used by us for the investigation were 20 out of a group of 50 of what is known as the 1888 type. This type we selected, since it was the latest constructed by the Electrical Power Storage Company. The particular specimens of this 1888 type, which are at the Central Institution, contain each two positive and three negative plates, each plate, exclusive of the lugs, being 9¼ by 9¼ inches. The glass vessels containing these plates are large enough to each hold 7L plates, but we preferred to use 7L glass boxes to having smaller boxes specially constructed.

The total weight of each of these cells is about 59 lbs. 12 oz., made up as follows:—

	lbs.	oz.
3 negative plates	about 17	2
2 positive ,, ...	,, 11	8
Ebonite strips.....	,, 0	8
1 glass vessel	,, 7	8
Dilute sulphuric acid.....	,, 23	2

and the cells are intended to be used with a maximum current of 9 amperes on charging and 10 on discharging.

The first point to settle with reference to the discharge was whether the resistance in the circuit should be kept constant, or whether as the E.M.F. fell the resistance should be varied in such a way as to keep the current constant. This latter method, although it involved much more labour, was adopted. At first the current was kept constant by varying the resistance by hand

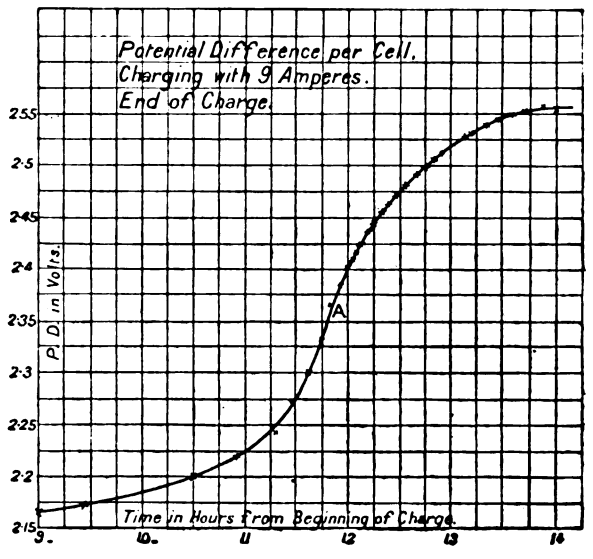

FIG. 1.

as the E.M.F. of the cells altered. But this required the constant presence of one of the observers day and night, partly to vary the resistance from time to time, and partly to start the charging directly the discharging was finished, in order that the cells might never be left discharged. Hence an automatic arrangement, which will be described later on, was subsequently devised, and by means of it the current was maintained more constant than could be achieved by even very careful hand regulation, and the circuit broken during discharging and during charging the moment the potential difference reached certain pre-arranged values.

We had next to adopt a criterion by which to settle when a charge or discharge could be said to be completed. Such a criterion may be made to depend on a variety of changes that take place in a cell, three of which are in common use—viz., change in the specific gravity, gassing, and change in the potential difference. In the case of the cells tested by us, and which have more liquid in proportion to the plates than is usually the case, the change in specific gravity from charge to discharge is from 1·2 to about 1·17: and, as our experiments show that the change is directly proportional to the time, when the current is kept constant, the change in the specific gravity per hour is only about 0·002, which is far too small to be read very accurately with ordinary hydrometers. But it is known the fall in the E.M.F of the cells at the end of the discharge is very rapid, so that half-an-hour more or less in the time of the discharge produces a great difference in the value of the E.M.F.; hence it follows that, if a specific gravity test were alone employed with our cells as a criterion of charge and discharge,

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Efficiency Tests of Accumulators.

Date.	Maker of cell.	Experimenters.	Efficiency. Quantity	Efficiency. Energy.	Remarks.
1882	Faure	Ayrton and Perry	...	82	Cells short circuited for some time before being tested. Cells discharged on three successive days, and allowed to recuperate during the two intervening nights.
1882	„	French Commission.....	92	70	Result of a week's work. Current kept fairly constant during discharge by the addition from time to time of fresh cells.
1883	Schultz	Hallwachs.....	...	6 to 50	Results variable and indefinite.
1883	E.P.S.	H. Morton	90	...	
1883	--	Aron	...	6 to 50	Results very variable.
1885	B.T.K.	Forbes	80	69	Mean of one week's work. Current not kept constant.
1886	Farbaky and Schenek...	Waltenhofen	91·7	78·7	
1886	E.P.S.	Drake and Gorham	90	80	Current maintained constant during charge and during discharge.
1887	—	Haeberlin	92	...	"Cells not good."
1887	Fitzgerald.....	Lea	91	...	
1887	—	Huber	...	88	
1887	C. Smith	Miller	80	...	Lead spirals painted over with salts.
1888	Huber	W. Kohlrausch.....	90·7	78·4	
1889	Farbaky and Schenek...	Waltenhofen.....	88·1	77·4	
1889	Tudor	W. Kohlrausch and Heim..	94	82·4	Normal currents used in charging and in discharging.
	„	„ „	77	64·7	Charging and discharging currents rather more than twice the normal.
	„	„ „	81·4	71·7	Cells allowed to rest for 160 hours after charging.
	„	„ „	90	80	Cells first completely discharged by the external resistance being gradually diminished to nought
					The positive plates of these Tudor cells are first formed by Planté's process, then the holes in the grids are filled with minium, and the forming continued. The negative grids are not formed at all, but merely have the holes in the grids filled with lead oxide.

it would be necessary to read the specific gravity accurately to less than 0·001 at the end of the discharge. The amount of gassing is also far too rough a test, and cannot be employed at all in the discharge, hence we were led to resort to the variation in the potential difference.

A number of experiments were now made on two of the cells in order that the *exact* shape of the curves of potential difference at the *end* of the charge and discharge might be ascertained. The curve shown in Fig. 1 is the end of the potential difference curve for one cell on charging with 9 amperes for 14 hours; from which we see that the rate of variation of the potential difference

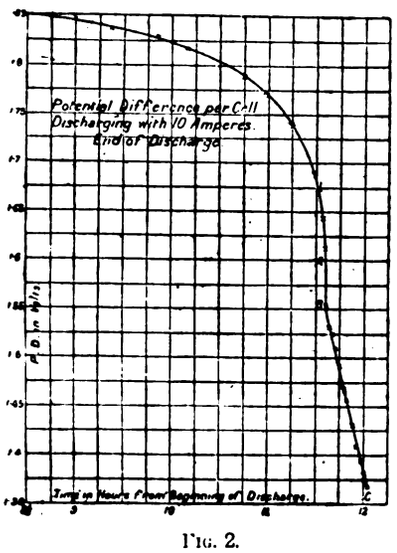

Fig. 2.

with time is greatest when the potential difference is about 2·36 volts, indicated by the point A. In Fig. 2 is shown the curve of potential difference during the last 3½ hours of a discharge with 10 amperes, the discharge being continued for 12 hours. In this particular experiment the discharge was allowed to continue until the potential difference fell to 1·365 volts, indicated by the point C, which is far lower than we have dared on any other occasion to allow the potential difference to fall. At about 1·8 volts the potential difference curve begins to fall pretty rapidly, and the slope of the curve, or the rate of diminution of the potential difference with time, goes on increasing until the potential difference has fallen to 1·6 volts, indicated by the point A on the curve in Fig. 2. Here $\frac{dV}{dt}$ per cell has reached a value 1·4, V being measured in volts and t in hours. Below this the curve has a shape that has not hitherto been noticed, for when the potential difference per cell has reached 1·556 volts, indicated by the point B, the curve suddenly alters its shape, becoming the straight line B C, with a less inclination to the axis of time, $\frac{dV}{dt}$ being for this line only 0·44.

Just as we have in the curve in Fig. 2 continued the discharge much below the usual limit, so we examined what would take place if the charging was also prolonged much beyond the usual limit. Curve 3 shows the rise of the potential difference when the charging at 4·52 amperes was continued for 37½ hours, 25½ hours being sufficient to fully charge the cells with this constant current of 4·52 amperes—that is, to charge them until the potential difference per cell was 2·4 volts. It will be observed that whereas the volts rise from 2·25 to 2·38 between 23·1 and 25·5 hours—that is, 0·13 volt per cell in 2·4 hours—the rise in the following 12·3 hours is only from 2·38 to 2·55 volts: this is only 0·17 volt. The continuation of the curve shows the drop of potential difference on breaking the charging circuit; there is an instantaneous fall of 0·28 volt per cell, and a further fall of 0·1 volt in the E.M.F. in two hours.

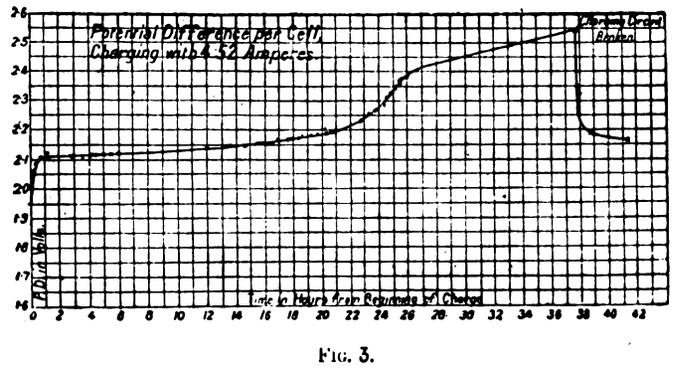
Potential Difference per Cell,
Charging with 4·52 Amperes.
Charging Circuit Broken.
Time in Hours from Beginning of Charge.

Fig. 3.

The curve on Fig. 4 shows on a larger scale this drop on breaking the charging circuit when the cells are very well charged, leaving it broken for five minutes, and then closing it again, the charging current in this experiment being 9 amperes. There is, we see, a nearly instantaneous drop of the terminal potential difference per cell from 2·56 to 2·31, then a steady fall in the E.M.F. from 2·31 to 2·24 volts in five minutes. On reclosing the charging circuit at this moment, there is an instantaneous rise of the potential difference to 2·48 volts, and then a slow rise to 2·56 volts in five minutes; so that after reclosing the charging circuit it took, in this experiment, the same time for the potential difference to recover the value it had just before breaking as the time during which the circuit remained broken.

Experiments were also made on the time rise of the E.M.F. on stopping the discharge. Later on, however, the time rise of the E.M.F. on breaking the discharge circuit, as well as the time fall of the E.M.F. on breaking the charging circuit, for various currents,

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was measured in a far more sensitive way than in the early part of this investigation; this subject, will, therefore, be left until further on in this Paper.

On starting a discharge the potential difference generally falls slightly to the value that is maintained fairly constantly during a long portion of a discharge. After a prolonged rest, however, we have found that the potential difference, on the contrary, shows a *decided rise* at the commencement of a discharge, and that it is not until the third discharge takes place that the curve resumes its normal character with the slight drop in the value of the potential difference at the commencement of the discharge.

II.—*Efficiency.*

In the earlier of the experiments made by us on the efficiency, two distinct groups, each of 10 cells, were employed. The current passing through the two sets of cells also passed through two platinoid strips, and the potential difference at the terminals of each of these platinoid strips was measured by a suitable low-resistance galvanometer, whose indications, therefore, measured the respective currents passing through the two sets of cells. The potential difference at the terminals of either group of cells was measured by means of a high-resistance D'Arsonal galvanometer, which by means of a switch could be connected with the terminals of either of the two groups. The high-resistance and one of the low-resistance instruments have been absolutely calibrated very frequently during the past few years, by means of the silver voltameter, known resistances, and Latimer-Clark standard cells. A special calibration was also taken of these instruments, both just before these experiments were commenced and at their conclusion.

Group No. I. of 10 cells was first charged with 9·05 amperes and discharged with 9·933 amperes, there being four discharges alternated with four charges, without intermission from January 8th to January 12th, 1889, both days inclusive. One of the observers was always present (day and night) to keep the current constant by hand regulation, to take frequent readings of the

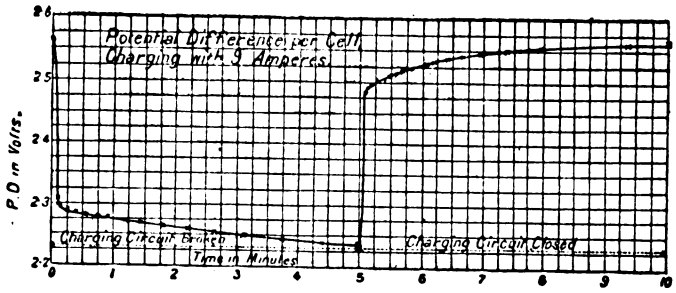

FIG. 4.

potential difference at the terminals of the set of 10 cells, to stop the charging when the potential difference per cell reached 2·4 volts, and immediately start the discharging, as well as to stop the discharging when the potential difference per cell reached 1·6 volts and instantly start the charging again so that the cells were never left discharged.

We used the limits 2·4 and 1·6 volts per cell as the criterions for stopping respectively the charge and discharge, since, as already seen, the slope of the charge and of the discharge curves are greatest for about these values of the potential difference.

Next, Group I. was charged with 4·519 amperes and discharged with 9,933 amperes, twice, without intermission, from January 14th to January 19th, inclusive, the potential difference limit for charge being 2·4 volts, and for discharge 1·5.

And while the two sets of tests were being made with Group I., Group II. was first charged with 9·104 amperes and discharged with 4·858, twice, without intermission, from January 9th to January 12th. And, lastly, Group II. was charged with 4·519 amperes and discharged with 4·858, without intermission, from January 14th to January 19th, both days inclusive.

Shortly, then, the tests were :—

	Charge.	Discharge.	
Group I.	9	10	amperes.
	4½	10	„
Group II.	9	5	„
	4½	5	„

The coarse adjustment of the resistance for keeping the current constant was effected by means of resistance coils made of bare German silver wire suitable for standing large currents. The fine adjustment was performed by means of horizontal mercury troughs through which the current passed, the lengths of the mercury in the wooden troughs through which the current passed being varied by copper bridge-pieces. This mercury trough arrangement forms an extremely convenient resistance for delicate adjustment by hand. To keep the current as constant as possible a dynamo was not used to charge the accumulators under test, but they were charged instead from other accumulators of much greater storage capacity.

The general expressions for the ampere-hours and watt-hours given out by an accumulator are, of course,

$$\int_0^{t_1} A_1\,dt, \text{ and } \int_0^{t_1} V_1 A_1\,dt,$$

where A_1 and V_1 are the current in amperes passing through the accumulator, and the potential difference at its terminals at any moment, and t_1 is the time in hours during which the discharge lasts. Consequently, if A_2, V_2, and t_2 have similar meanings for the charge, the complete expressions for the quantity and energy efficiency are, respectively,

$$\int_0^{t_1} A_1\,dt \div \int_0^{t_2} A_2\,dt,$$

and

$$\int_0^{t_1} V_1 A_1\,dt \div \int_0^{t_2} V_2 A_2\,dt,$$

In our experiment A_1 has a constant value during the discharge, and A_2 a constant value during the charge, so that the expressions for the quantity and energy efficiency reduce themselves to

$$\frac{A_1 t_1}{A_2 t_2}, \text{ which is very easy to calculate,}$$

and

$$A_1 \int_0^{t_1} V_1\,dt \div A_2 \int_0^{t_2} V_2\,dt.$$

To obtain $\int_0^{t_1} V_1\,dt$ a time curve of the values of V_1 is drawn and integrated; similarly, to obtain $\int_0^{t_2} V_2\,dt$ a time curve is drawn for V_2 and integrated; then, multiplying the first integral by the steady value of the discharge current A_1, and the second integral by the steady value of the charge current A_2, we have, respectively, the watt-hours given out in the discharge and the watt-hours put into the accumulators in the charge.

After drawing a series of time curves for the potential difference in the various experiments already referred to, and integrating them with an Amsler's integrator, we obtained the following results for the successive charges and discharges :—

Group of 10 *Cells.—No.* I.

Discharge at 9·933 amperes.		Charge at 9·05 amperes.		Percentage.	
Ampere-hours.	Watt-hours.	Ampere-hours.	Watt-hours.	Quantity efficiency.	Energy efficiency.
119	2,280	114	2,435	105	94
105	2,045	102	2,220	103	92
101	1,970	101	2,220	100	87
104	2,020	104	2,270	100	89
Discharge at 9·933 amperes.		Charge at 4·519 amperes.			
112·5	2,170	115	2,485	98	87
113	2,190	115	2,485	98	88

Group of 10 *Cells.—No.* II.

Discharge at 4·858 amperes.		Charge at 9·104 amperes.		Percentage.	
Ampere-hours.	Watt-hours.	Ampere hours.	Watt-hours.	Quantity efficiency.	Energy efficiency.
144·5	3,055	138·5	2,910	111·5	103
141·5	2,770	129·7	2,820	109	98
Discharge at 4·858 amperes.		Charge at 4·519 amperes.			
143	2,785	141	3,075	102	90·5

Now, not only are quantity efficiencies of 105, 103, 111, 109, &c., per cent. impossible, but energy efficiencies of 94, 92 per cent. are also too high, when accumulators are being charged and discharged at the maximum rate allowed by the manufacturers. Further, it is noticeable that for each set of tests both the quantity and energy efficiencies diminish on the whole as the tests proceed. These cells, like the other cells in the Central Institution laboratories, have

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been charged at regular times ; and as the number of ampere-hours taken out of them for ordinary laboratory work varies very much, the intervals between the periodic chargings are so arranged that on the whole the cells are charged up much more than they are discharged.

Hence, at the commencement of these tests the cells had a large store of energy in them on which to draw in the discharges, the results of which are given in the preceding table. From this we learn this very important fact—that *if accumulators be thoroughly well charged up before being tested, then five days' continuous charging and discharging alternately with even the maximum currents allowed by the manufacturers fails to give the normal quantity, or energy, efficiency.*

It will be noticed that both the ampere-hours and the watt-hours are increased by diminishing the current employed. This is partly due to the fact that if a fixed potential difference limit per cell be employed either in discharging or charging, the cell is discharged until the E.M.F. is slightly lower, and charged until the E.M.F. is slightly higher for a small current than for a larger one.

(To be continued.)

LEGAL INTELLIGENCE.

King, Brown, and Co., v. The Anglo-American Brush Electric Light Corporation.

JUDGMENT.

The First Division of the Court of Session (the Lord President and Lords Adam and McLaren on the bench) gave judgment on Wednesday in the action by King, Brown, and Co., Edinburgh, to reduce the patent No. 2,003 of 1878 of the Brush Corporation for compound-wound dynamo machines. A long proof was led in the Outer House before Lord Trayner, who thereafter reduced Brush's patent on the ground that it had been anticipated by Varley's patent, No. 4,905 of 1876, both by prior publication and by prior use. Against this judgment the Brush Corporation reclaimed to the First Division ; and the case was debated some weeks ago.

The Division adhered to the judgment of the Lord Ordinary.

LORD McLAREN, who read the judgment of the Court, said : The defenders, the Brush Electric Light Corporation, claim under their patent the exclusive privilege of making dynamo-electric machines in which the electro-magnets are of the type known as "compound-wound." The pursuers, King, Brown, and Co., are makers of "compound-wound" dynamos ; and their right to make such machines having been extra-judicially challenged, they have brought this action to have the defender's patent reduced and declared void on various grounds : the chief objection being that the invention of compound-winding was previously discovered and made known by Mr. Varley, and consequently that Mr. Brush or his assignees are not in the position of being the "first and true inventors" of this valuable electric appliance. There can be no doubt that the holder of Brush's patent claim compound-winding as an essential feature of their machine, and accordingly if this claim be ill-founded the patent must fall. The argument was directed mainly to the question of the anticipation of the Brush system of compound-winding by Mr. Varley ; and I shall consider this subject in the first place, touching afterwards on the objections to Brush's specification, which are of a technical character.

In order to make my observations intelligible, I must begin by stating in what compound-winding consists. In the rudimentary form of the dynamo-machine I understand that the excitation of the electro-magnets was maintained from a separate, or as it is termed an external source, generally a battery of some kind. The first improvement consisted in winding one of the conducting wires round the electro-magnets, the continuation of this wire being led into the external or working circuit. In this way the current flowing from the dynamo was made to maintain the magnetism of the electro-magnets as a part of the work which it had to perform. This is known as series-winding. The next improvement consisted in dividing the current as it flowed from the commutators into two partial currents. In this system the wire is bifurcated ; one branch is wound round the electro-magnets and is returned to the opposite poles of the commutator. The second branch wire is employed for lighting or external work of some kind, and is remitted to the first branch wire near where it meets the commutator at the opposite pole. This is the form known as shunt machine. The invention of compound-winding, with which we are here concerned, consists in, I will not say a combination of the two methods ; but with the addition of the shunt and the series method. The wire is divided or bifurcated as it leaves the commutator. Both the branches are wound round the electro-magnets. One of these is directly returned to the opposite pole of the commutator without doing any work other than the excitation of the magnets. The second wire on leaving the electro-magnets is continued to form the external or working circuit, and is ultimately re-united to the first wire. This arrangement seems to be an exception to the rule against trying to do two things at the same time : because it is admitted that the compound-wound machine is a much better working machine than the shunt. It appears that the sections of the wire can be so proportioned that a nearly uniform current flows in the working field, notwithstanding variations in the quantity of work to be done. It is not necessary for the purpose of the case to explain why this should be ; and, if it were necessary, I am not sure that I am able to explain it. It is a question of the mathematical theory of current-electricity. But it is agreed that the compound wound machine, when the wires have the proper relative conducting capacity, gives better results as regards uniformity and steadiness of the current than are attained by either the series or the shunt ; and this explains the importance of the right to use this invention to the parties concerned.

I may here observe, it is not clear to me that either Varley or Brush were at first fully aware of the scientific and practical importance of the principles of compound-winding. Varley was the inventor, or one of the inventors, of the "series" machine ; and both Varley and Brush were doubtless, aware of the advantages and disadvantages of the "series" and the "shunt." The idea of introducing the two methods into the same machine is one that would very naturally occur to any one familiar with the subject and practically conversant with dynamo machines. Assuming that this is intelligently done, with the object of getting a better working machine through the union of the series and the shunt than is attainable by either of these modes of winding singly, then the invention is a proper subject of a patent, and it is not necessary to its validity that the patentee should have foreseen all these advantages which have been realised through a subsequent introduction of electric lighting with the incandescent lamp. I may also observe that in Brush's specification, as well as in Varley's specification, the mode of winding is only treated as one among many other parts of a dynamo-machine ; and it is quite possible that a reader, even if conversant with the subject, might peruse either of these documents without having his attention specially called to the novelty of the system of compound winding. But neither will this consideration affect the question. An inventor may describe his invention clearly without proclaiming it as a very important discovery, and the question is whether compound winding is clearly described in Varley's specification.

The specification in question is No. 4,905 of 1876, and its title is "Improvements in apparatus for producing the electric light, parts of which invention are applicable to other purposes." The alleged anticipation is contained in the two paragraphs, page 4, lines 11 to 21 :—"Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light." I interrupt the reading to remark that, in the words I have read, the writer only announces what he is going to do, and does not profess to be explaining his method. This obvious and I should have thought superfluous criticism disposes of many pages of evidence in which witnesses are brought to say that these words would not give them a clear idea of the method of winding. The specification proceeds :—"There are several well-known ways of doing this" (that is of diverting a part of the electric energy developed by the machine) ; "but the method I prefer is to wrap the soft iron magnets with two insulating wires, one having a larger resistance than the other. The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light." If the description had stopped here, I should not have doubted that it contained a clear description of the *construction* of a compound-wound machine. I mean a description of so much of the apparatus as is included in the name compound-winding. The direction is to wrap the magnets with two insulating wires ; it is, of course, implied that these wires are to carry currents coming from the machine ; but this is not left to implication, because it is clearly explained that these insulating wires are the media for the transmission of separate currents, the one of larger resistance being always closed (in other words, acting as a shunt), while the other is used for the electric light (having previously contributed to the magnetisation of the magnets by being wrapped around them). But if the description had stopped here, it would have been open to the observation that while it described the construction it did not indicate, except in a very general way, the use of the compound machine of the magnets. Now I could hardly consider that to be an adequate description of an invention which should leave the reader in ignorance of its utility and its mode of action. But the information which I desiderate is supplied by the second paragraph : "When the electric light is being produced the greater portion of electricity passes through the circuit of less resistance, which I term the 'electric light circuit,' maintaining the magnetism of the magnets and producing the light. When the electric light circuit is open from any cause the electricity developed passes through the circuit of greater resistance only and maintains the magnetism of the magnets." There is here plainly described one of the advantages of the compound-wound dynamo, probably the only one known to the writer, viz., that when work is being done in the external circuit, the magnets have the benefit of the unobstructed flow of the electric current through the wire of larger resistance and less resistance, while when the external circuit is open and no work is being done, the magnets receive through the wires of greater resistance the current which is sufficient for their excitation. I am here merely paraphrasing Mr. Varley's description without meaning to add anything to it ; and I think that anyone conversant with the subject, and reading this paragraph (whether he agreed with Mr. Varley or differed with him as to the possible benefits to be attained), would not be left in doubt as to what Mr. Varley considered to be the *rationale*, and the mode of action of the arrangement of wires described in the preceding sentences.

I have difficulty in understanding how it is that a considerable number of able and distinguished men should have been persuaded to give their evidence as to the alleged insufficiency of Mr. Varley's description as an anticipation. To a considerable extent the evidence of the witnesses of the Brush Company is made up of somewhat minute and verbal criticism on the expressions used by Mr. Varley ; but, in so far as these gentlemen indicate an opinion as to the insufficiency of the description in its entirety, I think their conclusions are in part explained by their having misapprehended the question ; because I observe that the question is frequently asked and answered whether Varley's specification is such as

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would enable an ordinary workman to make a compound-wound machine. Now, the question of anticipation does not depend (in our opinion) upon that test. We are not here trying the sufficiency of Varley's specification as a specification. Varley is not here claiming any exclusive privilege (his patent has long since expired); and we have no occasion to consider whether he fulfilled the duty which is the counterpart of the exclusive privilege given to a patentee of particularly describing and ascertaining the nature of his invention and the manner in which it is to be performed. I am very far from saying that Varley's specification is insufficient as a specification of a patented invention. I rather think it would be held to meet the requirements of the statute of King James. But the question we are now considering is quite different; it is whether Mr. Brush is or is not the first and true inventor of compound-winding, and the negative of that proposition may be proved by showing that the invention was previously described, not necessarily in language sufficient as a direction to a mechanic, but in language clear and intelligible to educated men conversant with the subject, and capable of giving the necessary directions to the hypothetical workman. An invention may be clearly described in mathematical or chemical symbols, the latter being perhaps the preferable illustration. Such a description, although it may have to be translated for the instruction of the operative chemist (just as if it were written in a foreign language) would be an anticipation of the same invention described in popular language, such as is required (as far as practicable) by our Patent Law. Now, I venture to think that if Varley's description had been put into the hands of any of the defenders' witnesses (without reference to any question under the Patent Laws) that he would have understood it, and would have been able to instruct a workman to make an experimental machine. I think I can collect from their evidence that the witnesses on both sides understood the specification perfectly, although some of them were certainly apprehensive that other persons less gifted would not find it so easy to be understood.

It is a remarkable circumstance in this case that neither in the course of the trial nor in the argument addressed to us has any reference been made to Brush's description of compound-winding. It seems to have been assumed that it at least was a pattern of clearness, and certainly no objection was taken to it on the ground of insufficiency. Brush's description is contained in the following passage in his specification:—"In applying my invention to dynamo-electric machines, I wind the cores of the field-magnets with a suitable quantity of a comparatively fine wire, having a high resistance in comparison with that of the external circuit and the rest of the wire in the machine. The ends of this wire are so connected with the other parts of the machine that, when the latter is running, a current of electricity constantly circulates in said wire, whether the external circuit be closed or not. The high resistance of this wire prevents the passage through it of more than a small proportion of the whole current capable of being evolved by the machine; therefore, the available external current is not materially lessened. When this device, which I have called a 'teaser,' is used in connection with field-magnets, also wound with coarse wire, for the purpose of still further increasing the magnetic field by employing the main current for this purpose in the usual manner, then the 'teaser' may be so arranged that the current which passes through it will also circulate in the coarse wire, thus increasing the efficiency of the device." Now if Varley's description be insufficient, I do not see how the validity of Brush's patent can be maintained, because the two descriptions are practically identical. Conversely, if the invention of compound winding be well described in Brush's specification, the identical description in Varley's specification must be an anticipation. I do not mean, of course, that the language of the two descriptions is absolutely identical. In describing the shunt arrangement, Brush calls it a "teaser" (I do not know whether electricians attach any significance to this vocable), and there are some other variations of expression. But I can find nothing of substance in Brush that is not in Varley, and I cannot help adding that if there be any difference, Varley's description is the more easily understood of the two. This completes what I have to say on the subject of anticipation by prior publication.

There is also a plea of anticipation by prior use. On this point the facts are these:—In the interval between the filing of the provisional and complete specifications, Mr. Varley had a machine made to his direction by the firm of Siebe and Gorman. When the machine was first tried it did not work well, because its frame was not sufficiently strong to prevent the revolving armature being attracted into contact with the electro-magnets. I need not say that the motion of the armature must not be resisted by friction, but only by the immaterial though not less real resistance offered by the forces developed in the magnetic field. This was corrected by strengthening the frame, and the machine was successfully used in the production of an arc light by the lamp produced along with the machine. Siebe and Gorman are makers of diving apparatus, and the lamp was used on their premises to exhibit the apparatus under water in a tank which they had for the purpose. The case on public use is narrow; but we consider that what I have described is public use as interpreted by decisions. The machine in question was produced, and it is a compound machine; nobody has said anything to the contrary, though some of the defenders' witnesses say that if the wires were uncoupled, or were coupled up in a different way, it would no longer be so. But the effect of uncoupling the shunt wires would be to render this part of the winding simply useless for any purpose, as would indeed be the case with a machine of any kind if a material part of the mechanism is put out of its place or turned the wrong way. The Lord Ordinary has in his judgment extracted some of the more noticeable expressions of opinion by the scientific witnesses on the questions of prior publication and prior use, and has pointed out the insufficiency of the reasons given for holding Varley's specification to be incorrect or incomplete. I concur in the Lord Ordinary's view as to the weight to be attached to this part of the evidence, and in his lordship's opinion generally on the facts of the case, except in so far as he may be held to imply that the test of the sufficiency of an anticipation is the same as the test that would be applied to the construction of a specification founded on as such.

There is another objection to the defender's patent, and it is founded on an alleged inconsistency between the provisional and the complete specifications. The provisional specification announces as one of the improvements for which the patent is granted an improved construction of the commutator. The function of the commutator is to convert the alternating currents (as they pass from the revolving axis to the external circuit) into one continuous current. This is accomplished by fitting the axis in insulated segments, to which the poles of the armature are connected by insulated wires, and these segments are so arranged that at the moment when the current in the machine is reversed, the external wire becomes disconnected from the corresponding segment, and is at the same time brought into connection with the segment which is attached to the opposite pole of the armature. The improvement indicated in the provisional specification is a purely mechanical improvement for the purpose of obtaining a mechanical advantage. But, in the course of perfecting his invention, Mr. Brush found that an electrical advantage might also be secured by means of a slight variation of the mechanical arrangement indicated in the provisional specification. The variation consists in separating the segments; so that, for a small fraction of each semi-revolution, the current shall be interrupted; that is to say, the current is cut off during the brief interval when the armature (or the particular member of the compound armature) is in a neutral position, and when the resultant of the forces acting on it is therefore very small. In the complete specification, the variation whereby this electrical advantage may be gained is claimed as one of the patented improvements; and the question arises whether this difference between the provisional and complete specification does not exceed the latitude allowed to an inventor who is only perfecting what he has provisionally announced. The Lord Ordinary has held that the claim referred to is not covered by the provisional specification, on the ground that, although the construction of the commutator as perfected is not materially varied, yet as the variation represents a distinct principle and is directed to an object distinct from that which is indicated in the provisional specification, the two things cannot be regarded as identical inventions. There is much force in the Lord Ordinary's view on this question; but we consider it unnecessary to come to a decision upon it, because we are all of opinion that if there had been no more serious objection to the Brush patent than this, it would be only fair to the patentee that he should be allowed an opportunity of disclaiming this variation on one of the patented improvements. But this is not the condition of the case as it arises for decision, because we are agreed that the patent is invalidated in its essential and fundamental principle by reason of the prior publication and prior use by Varley of the invention of compound-winding, for which this exclusive privilege is given. For these reasons I am of opinion that the interlocutor of the Lord Ordinary should be adhered to, and decree of reduction of the patent pronounced.

The LORD PRESIDENT: That is the opinion of the Court.

On the motion of Mr. DANIELL, counsel for King, Brown, and Co., the Brush Corporation were found liable in expenses.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 3, 1890.

Electricity in the Brooklyn Navy Yard.—One of the interesting sights at the Brooklyn Navy Yard just now is the application of the electric motor for operating metal drills. Four large vessels are now building, and in the immense amount of boring that has to be done it will be hard to get along without mechanical drills. Both steam and electric machines are now in operation; but the latter appear to be far more convenient, and are great favourities with the Navy Yard authorities. The apparatus consists merely of a small motor enclosed in a tight case, which supports the necessary gearing to reduce the speed so as to operate the drill directly through the medium of a flexible shaft six or eight feet long. From ½ horse-power to 1 horse-power is required to operate the drills, which is supplied from the lighting plant in the yard. Two workmen are required to manipulate the apparatus. It takes less than 30 seconds to bore an inch hole through a half-inch plate. One of the electric drills is now at work on cruiser No. 7, the keel of which was laid a short time since; a couple more are working on the armour plates of one of the monitors, and others are in use in various construction work around the yard.

Edison's Electric Traction Experiments.—It is reported that Mr. Edison has again taken up the experiments on electric railroads that occupied much of his time a year ago; but it has not yet transpired whether anything practical is to come of his work. The original plan was to use potentials so low as to enable the track system of conductors to be used without

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severe leakage. For city work a system of this sort is greatly to be desired, and everyone will watch with great interest the developments that may come from these experiments.

The Consolidation of Electrical Interests.—The rumours of consolidation between the Thomson-Houston and Edison Companies, which have been floating about in an indefinite shape for some months, have at last resulted in the announcement that a powerful syndicate, which is headed by Mr. Henry Villard, and is engaged in some huge railway enterprises, is also taking up electrical matters, and owns, or is about to acquire, large interests in the above companies. Mr. Villard has for some time been identified with the Edison Company; but there is probably nothing like a consolidation on foot, although there may result some understanding between the companies to lessen the effect of business rivalry, which has been very severe. It is not yet known whether any interest in the Westinghouse Company will be acquired by Mr. Villard's syndicate.

The Westinghouse Electric Railway Company.—Of the Westinghouse Electric Railway Company, the organisation of which was announced some time since, little is being heard at present. It has taken some contracts, but has not yet put any apparatus on the market. Its motors, of which there are to be two upon each car, are said to bear a striking resemblance to the Thomson-Houston and Sprague motors in general appearance, although it is understood that a ring armature will be used instead of the Siemens winding, adopted by most of the other companies. Experiments are being conducted in Mr. Westinghouse's private workshop, and very little is allowed to escape concerning the methods or results of what is being done.

CORRESPONDENCE.

LEAKS ON ELECTRIC LIGHT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The fol'owing remarks on leaks may be of interest to your readers. To thoroughly know the ways, habits, and annoyances of leaks, I recommend students to the incandescent leads of a modern man-of-war. Ashore I imagine in a well-built house the chief danger from damp is caused by the wandering servant-maid and her can of water; at sea we have the more experienced combination of the Clerk of the Weather and Father Neptune, to say nothing of a fire-hose used with great zeal but little discrimination by the sailor during that electrically heart-breaking operation "washing down after coaling." To preserve our circuits in good order it is necessary not only to detect and repair leaks, but to foresee and forestall their occurrence. To do this in modern iron ships, which can scarcely be called "dry" in even moderate weather, and which are a mass of pipes and secondary circuits, it is necessary to know the exact position of every switch, cut-out (of which there are some thousand or so in a large ship), and lead, relative to all steam, water and hydraulic pipes, gun indicator and bell circuits, as well as places where leaks are likely to occur at sea. But, above all, it is necessary to have a keen eye and good nose.

Broadly, leaks may be divided into two classes—earth leaks and contact leaks. Both may be equally dangerous, but the earth leak can as a rule be fairly easily found; the contact leak is extremely difficult to detect.

In answer to your first question in the last issue of *The Electrician* — "Can damp wood, or plaster, damage sound cable?"—I am inclined to say not; but damage may easily be done to wires securely cased in wood, which do not show till the damp gets at them. I will give one example: Ordinary india-rubber and tape-covered wires are often laid in wood-casings, and putty placed round them. The putty grips the insulation in places, and holds it firmly. If a strain be now put on the wire, as in carelessly refitting a lamp-holder or switch, the insulation is very liable to strip, and the fault to remain undetected below the putty; this will not show till water gets at the place. Undoubtedly, a small leak, in damp wood, will increase, though it is not necessary to increase to become extremely dangerous. I take it the following is the life-history of most heated casings through a small contact leak:—

(1) A small leak in the insulation of both wires, most commonly where two branch wires are forked in.

(2) The casing becomes damp and so connects the two.

(3) A slight electrolytic deposition in the pores of the wood; therefore,

(4) Better conduction and a heating of the particles.

(5) Gradual charring of the wood, but still a high resistance.

(6) Circulation of air and the casing on fire.

Only a week ago I had two such cases, one where the leads to a 16 candle-power 80 volt lamp were forked into a submain; there was no sign on the outside, but inside the casing was charred for several inches. The other case, where the paint outside was blistered, was caused by the insulation being damaged by one of the screws of the casing; the casing was charred inside, the leak this time was to earth.

It is this class of leak that is so dangerous. A big leak is nothing, the cut-out goes—that is all; but the small leak works its wicked will with a current totally inadequate to fuse the cut-out.

I do not think the case of a 20-ampere leak likely to occur through a damp casing. The casing would be on fire long before, unless the wires were very close together; anyhow, with 20 amperes running normally in the wires, an addition of another 10 or 15 would certainly determine the cut-out going. A question arises, should cut-outs be put in to fuse according to the number of lamps or the current capacity of the wire? From practical experience I am inclined towards the latter, for an increase in current of a few amperes in a sub-main can be caused by many things, which themselves are practically harmless, such as an accidental rise of a few volts or many small leaks at damp switches and cut-outs. The result of too fine an adjustment means endless trouble and complaints, while the real danger lies in currents for which it is impossible to adjust owing to their smallness.

There is no method that I am aware of with ordinary insulated wires which can prevent a casing catching fire through a small leak through damp wood. I therefore prefer to use my cut-outs solely to guard against my wires heating, and trust to a good look out for leaks, wet places, and blistered paint to prevent fires.

With the lead-coated wires now introduced into the service casings are done away with, and the wires are as wires should be—in sight, with careful fitting and well-soldered joints in the lead piping. I have never heard of complaints; but a badly soldered joint is worse than useless in a damp place. To my mind lead-coated wires laid on a metal strip is the safest possible way to wire. Any fault, dangerous enough to heat the wires, soon causes the cut-out to go, the metal strip protects the wood. The result of my experience of leaks has been: to pray, if leaks occur—and they are sure to—that they may be big ones.—Yours, &c., R. H. BACON, Lieut. R.N.

H.M.S. "Camperdown," July 12, 1890.

PRIMARY BATTERIES FOR LIGHTING PURPOSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent, "Electromaniac," seems to have altogether lost sight of the fact that the voltage depends upon the number of cells in series, and that each cell consumes an equal quantity of zinc. His figures, therefore, require to be multiplied by the number of cells used. The amount of zinc dissolved is not per ampere, but per volt-ampere or watt. As no one else appears to have made this correction, I do so, lest any of your less advanced readers may be misled by the statements made.—Yours, &c., F. G.

Underground Telegraph Lines in Germany.—The Direction of the Posts and Telegraphs has applied for the sum of 1,250,000 marks (£625,000) for the extension of the underground telegraph lines on the Bavaria-Saxony frontier from Hof-uber-Chemnitz to Dresden.

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BOOKS, &c., RECEIVED.

"Derivation of Practical Electrical Units." By Lieut. F. B. Badt and Prof. H. S. Carhart. (Chicago : Electrician Publishing Company.)

"*Transactions* of the Royal Society of Victoria." Vol. I., Part 2. (Melbourne : The Spectator Publishing Company.)

"Electric Light Fitting." By John W. Urquhart. (London : Crosby, Lockwood and Son.)

"Picturesque Wales." (London : Simpkin, Marshall and Co.)

"Technology Quarterly" (Massachusetts Institute of Technology, Boston).

"*Journal* of the Institution of Electrical Engineers." Vol. XIX. No. 88. (London : E. and F. N. Spon.)

"The Electrical Engineer's Pocket Book." (London : Crosby, Lockwood and Son.)

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The Directors of the Stockholm Gas Works require tenders for the erection of a central station for the town of Stockholm, either in whole or in part, which will be received up to September 1st. The installation for which the tenders are invited comprises machinery, accumulators, &c., for 10,000, and underground leads for 15,000 lamps of 16 candle-power. Further details are given in our advertising columns, and specification and full particulars are to be obtained from the Stockholm Gas Works, price 10s. per copy.

TENDER ACCEPTED.—The tender of Mr. C. F. Kearley, of Uxbridge and Kensington, has been accepted for erecting new offices and stores at West Drayton, for the Electrical Engineering Corporation (Limited).

CHEAP GLASS SHADES FOR ELECTRIC LIGHTING.—We have received from Messrs. T. and W. Ide, the well-known glass makers, some excellent samples of cheap glass shades. These are made in five colours by a process of manufacture covered by a patent. The colours are bright, and are specially selected for harmonising with the electric light. Prices range from 6s. to 9s. per dozen. Large quantities are kept in stock, and, we understand, can be supplied at a few hours' notice. A large assortment of glass globes and shades, &c., can be seen at Messrs. T. and W. Ide's Show Room, Glasshouse Fields, Ratcliff, E.

MESSRS. J. AND J. BLAIR, OF KILMARNOCK.—Messrs. Blair intimate that they have added to their business a department of mechanical and electrical engineering, to be under the superintendence of Mr. James Campbell, late of Messrs. Anderson, Campbell and Munro (Limited). Messrs. Blair will manufacture, amongst other things, the Campbell dynamo and arc lamp and also Campbell's patent ship's electric telegraph.

THE "TRICHORD" LIGHT ADJUSTER.—Mr. W. S. Boult, of Liverpool, sends us particulars of a new suspension fitting for incandescent lamps, which he calls the "Trichord" Light Adjuster. A small brass boss with three radial arms screws on to an ordinary lamp-holder, taking the place of and acting as the usual cord-grip. A little brass basin-shaped block is supported in the proper position on the hanging conducting wires by an indiarubber washer inside it, and the block and radial arms are connected by an endless silk cord.

PERSONAL.—We understand that Sir Benjamin Baker has accepted the position of engineer to the Watkin Tower Company.

ELECTRIC LIGHT CARBONS.—Messrs. Cathcart and Peto inform us that they have been appointed sole agents for the sale in this country of Emil Mahla's electric light carbons, of which they are keeping a large stock in London. It is claimed for these carbons that they give an unusually white light. A price list has recently been issued, giving temperatures and cost of both solid and cored carbons.

REMOVAL NOTICE.—Mr. Ernest J. Gillett, late of 26, Red Lion-square, Holborn, informs us that the business of telephone engineer, until recently carried on by him at the above address under the title of the Electric Telephone Company, has been removed to larger premises at Hermitage Works, Richmond, Surrey.

"THE ELECTRICIAN"

ELECTRICAL TRADES' DIRECTORY & HANDBOOK for 1890

The 1890 edition of our well-known Directory and Handbook is now ready. The book consists of 850 pages, and contains a mass of most useful information. The DIRECTORY DIVISION consists of more than 400 pages, and contains a very carefully compiled Alphabetical and Classified List of Firms and Persons engaged in the Electrical and Allied Trades in all parts of the world. This Division has been corrected up to date, and the book is *thoroughly reliable*, even the very numerous changes which take place in the month of January being incorporated. The book is not a mere list of known and unknown Members of Scientific Societies repeated again and again. The Colonial and Foreign Division will be found extensive and reliable. The book has been very favourably reviewed by the Press. The price is 5s. 6d., post free in the United Kingdom.

COMPANIES' MEETINGS & REPORTS.

Eastern Telegraph Company (Limited).

The thirty-sixth half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held yesterday at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. George Draper) read the notice convening the meeting and the minutes of the previous meeting, which were confirmed and signed as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said that the resolution which he had to move was :—

"*That the printed report and accounts of the Directors to 31st March*, 1890, *submitted to this meeting be, and the same are, hereby received and adopted. That a dividend on the Preference Shares of the Company to 30th June*, 1890, *at the rate of 6 per cent. per annum, be paid less income-tax; and that in accordance with the Directors' recommendation a dividend be and is now declared of 2s. 6d. per share, with a bonus of 3s. per share, both free of income-tax on the ordinary shares of the Company, making with previous payments by way of dividend on account a total payment of 6½ per cent. on those shares for the year ended 31st March*, 1890."

The VICE-CHAIRMAN (the Marquis of Tweeddale) seconded the resolution.

The CHAIRMAN said that, before asking them to approve of this resolution, he would, as usual on these occasions, make some remarks upon the report, and give them some general information as to their working during the last six months. The revenue for the half-year ending March, 1890, amounted to £424,023, being a decrease of £11,909 as compared with the corresponding half of 1889. But the balance brought forward from the September half-year account was £61,151, being an increase of £24,535, as compared with the corresponding period of the previous year. They had, therefore, an increased available amount to deal with of £12,626. It would be observed that their dividend on Direct Spanish shares was £246 more than in the corresponding period, and he had much satisfaction in calling attention to the dividend which they had received from the African Direct Company, namely, £1,500, being at the rate of 4 per cent. per annum for the past half-year. The African Direct Company was formed to carry out an important work—the establishment of telegraphic communication with the British Colonies on the West Coast of Africa ; but the local traffic of the line was very small, and even with the subsidy received from the British Government, the Company was unable to meet its working charges. Now, however, that it had a share in the South African through traffic, the African Direct Company was showing a small profit, and they might hope that in the future their investment in that Company would be a fairly remunerative one. The total working expenses for the half-year to March, 1890, amounted to £98,477, being an increase of £6,029. There was an increase of general expenses in London of £738 in salaries, office expenses, rent, stationery, printing, &c., consequent upon the continued development and expansion of the Company, necessitating additional staff and accommodation. Working expenses at stations showed an increase of £4,132, the principal item of which was in the salaries of their station staff at home and abroad which was fully explained and approved at the last general meeting. The number of staff at stations in March, 1890, was 637, against 582 in 1889, or an increase of 45. On the other hand, several of the items under Abstract B showed a decrease, namely, repairs and renewals of furniture at stations £1,109 ; repairs to stations, £423. Depreciation of cable stock was also less by £654. Repairs to cables amounted to £47,520, being a decrease of £1,145. Full details of the expenses of the ships, &c., and cables used on repairs, would be found on reference to Abstract C in the accounts. They would find as a charge against revenue fund a sum of £5,397 for loss owing to a bank robbery at Athens. This loss was incurred in May, 1889. They had not dealt with it until now, as they had been employing every available means to recover at least a portion of the amount. They regretted that their efforts so far had been unsuccessful.

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After providing for all expenses and interest charges against revenue they were able to recommend a final dividend at the rate of 5 per cent. per annum, and a bonus for the year of 1½ per cent., making a total distribution of 6 per cent. on the ordinary shares. They carried £125,0˙0 to the general reserve fund, which now amounted to £607,000. When he last addressed them he referred to the West Coast system as being fully completed, and which he believed at the time would give them important results. He was glad to confirm that opinion now. Altogether, they were in a position to meet all the requirements in the development of that dark territory which had been so much before their notice for the last few years. As he had remarked on a previous occasion, they were prepared to do their part in connecting that new world with the old, which would be not only to the interest of civilisation, but of material advantage to the shareholders. He had also told them that they had had some little trouble in Egypt. He might mention that, some time ago, he proceeded to that country, and the result of his visit had been that they had settled affairs there in such a satisfactory way, that there would be a substantial benefit to the Company as well as to Egypt itself from their negotiations. Their relations with that country were now in a satisfactory condition and most likely to be so for many years. He had also referred to the forthcoming Conference, and told them that at Berlin they had made considerable sacrifices. At the recent Conference in Paris, the Company was very ably represented. There was not a point that was not fairly discussed, and he was bound to say that the general body of the Conference representing the different European Governments acted, upon the whole, in a very fair and satisfactory manner to the Company. He had mentioned that they had no vote at those Conferences. They could only exercise their influence by placing before the representatives hard facts. As a rule, those facts were fairly dealt with; and he could say, without fear of contradiction, that the relations of the Company with the different Governments of Europe were never better than at the present time. The result had been that they came away from the Paris Conference with more satisfactory terms than they had done from any previous Conference. Small reductions in the Continental tariffs had been made; but he had no hesitation in saying, watching, as he did carefully, the progress of telegraphy, that before another year passed they would recoup the loss thus made by an increase in the number of messages. Their relations with India had very materially improved. That country was represented by a man of considerable intelligence and telegraphic knowledge, and the result was that the principle of give and take had been acted upon with highly beneficial results to all concerned. The Eastern Extension Company were going to reduce their rates, and what that Company did on the one side the Eastern Company had to support more or less on the other. They were, therefore, parties to an arrangement with the Eastern Extension Company whereby the Australian tariff would be reduced from 9s. 4d. to 4s. a word, the Governments of the Colonies guaranteeing to make good half the loss sustained by the reduction. This reduction must necessarily lead to a very considerable extension of business with Australia. Their Red Sea cables had been in operation nearly twenty years, and hence they would not be doing their duty to the telegraphing public if they did not at once prepare for that increase of traffic by laying another cable in the Red Sea from Suez to Aden, which they expected to have completed before the end of the year. They thought it was only fair to pay, as far as they possibly could, for that cable out of their reserve fund, so as not to add their capital, a policy which he hoped the shareholders would approve. He thought that from the statement he had made they would be satisfied that the Company was in a sound and satisfactory condition.

Mr. CLARKSON adversely criticised the general policy of the Board.

The CHAIRMAN, in reply, said that Mr. Clarkson who had come there to make a malicious attack on the Directors was an old servant of the Company, and he refused to answer him. He then put the motion in the usual way, and it was carried unanimously.

Mr. JAMES GIBB trusted that they would not regard it as an improper intrusion into relations more sacred than business relations if he expressed the deep sympathy of the shareholders with the Chairman, in the affliction which they all knew him to have suffered. He would also express their obligations to Sir John Pender and Sir James Anderson for so ably representing the Company at the late Conference. He moved—

"*That the shareholders of the Eastern Telegraph Company (Limited) here present desire to express their sincere sympathy with Sir John Pender and his family in their present severe affliction.*"

Mr. JOHN NEWTON seconded the resolution, and paid a warm tribute to Sir John Pender for the great services he had rendered to telegraphy generally, and to the Companies particularly over which he presided.

Dr. WALLER briefly supported the motion, and bore testimony to the courtesy and kindness of the Chairman in all his dealings.

The vote of condolence having been agreed to,

The CHAIRMAN, on behalf of himself and family, feelingly returned thanks, and the proceedings terminated.

(*A full Report will be given in our next issue*).

Telegraph Construction and Maintenance Company (Limited).

A half-yearly general meeting of this Company was held on Tuesday, at the offices, Old Broad-street, under the presidency of Sir George Elliot, Bart., M.P.

The MANAGING DIRECTOR (Mr. William Shuter) having read the notice,

The CHAIRMAN said: Gentlemen, you are aware that we have no accounts to present at these half-yearly meetings, nor, indeed, have I much to say beyond assuring you that, during the half-year which has ended, we have done as fair a share of work as we could have expected. Our factories are not idle at the present time, and our prospects for the remainder of the present year are encouraging Among the cable work executed I may mention that we have laid a duplicate cable between Australia and New Zealand, about 1,200 miles in length. As regards our general gutta-percha business, independent of submarine cable work, it has been satisfactory.

The proceedings then terminated.

The National Telephone Company (Limited).

The tenth ordinary general meeting of the Company was held on the 11th inst. at the City Terminus Hotel, Cannon-street; under the presidency of Mr. Frederick Richards Leyland.

The SECRETARY (Mr. Thomas Blaikie) read the notice calling the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—I propose to address you shortly with a view of elaborating and explaining some of the paragraphs in the report. The first thing that I have to remark upon is the fact that the whole of the amalgamation expenses, by which I mean the Government tax on the increased capital necessary, and the tax also on the transfer from the United and the Lancashire and Cheshire Companies to the National, we have thought desirable to put into the year's working. The great object of that is this: in making up these accounts we have gone upon this principle, that everything that could properly be put to the expenses of the year ought to be put to the year and paid out of the year's revenue. In drawing the distinction between capital and revenue expenditure, of course, there are many things about which there could be no doubt whatever; but in all cases in which there was any doubt as to whether an item ought to be put to capital or to revenue expenditure, we thought it desirable to err on the side of putting it to revenue, leaving capital as little augmented as we possibly could. Of course, in a business like this, the extension of our operations must be provided for by capital; but in all cases we have erred on the side of putting it to revenue, and I think that is a policy which will commend itself to the shareholders generally. Then we come to what, after all, is perhaps the most important thing we have to consider to-day, and that is the concluding lines of the first paragraph:—"In view of the near expiration of the Company's patents, the Directors think it prudent to strengthen the reserve account; and they propose, under Article 113 of the Articles of Association, to transfer to this account £40,000, leaving £11,113. 9s. 7d. to be carried forward to next year." Well, we recommend that pretty much on the same principle that we have adopted in making up the accounts. We think it is a desirable thing to strengthen our position by having large reserves and declaring a moderate dividend, which I think, and I hope you will all agree with me, is not an unsatisfactory one. As it is stated here that is, of course, mainly in view of what is going to happen when our patents are out. We cannot shut our eyes to this fact that competition may arise. We know that one Company is already formed to begin a competing service in Manchester. I dare say you all know that as well as I do. Fortunately, I think I am justified in saying that that Company does not appear to be a very strong one. I think also that they will find that they have a great deal to learn. The first patent expiring is the Bell receiver, which takes place in December of this year. I may tell you, and I believe it is a fact, that it will be utterly impossible for the Company I have referred to to carry out their business, as they say they will, on the expiration of that patent. They might be able to use this receiver for a small exchange with considerable advantage, but in a large exchange they will find it utterly impossible to do so. They will have to wait until the second patent expires in July, 1891—that is the Patent Edison Transmitter. Even when they get that they will find that there are other patents which do not expire until 1893, and which, although I will not say that they are absolutely necessary, are of material advantage in carrying on a good service As for the first patent that expires, I do not think they can carry on any service at all with it—that is the exchange service, which is not very good. I dare say that all of you have read with a good deal of interest the letters that have appeared from time to time in the newspapers both from the Mutual Company and from others who are not connected with that Company, but who seem to take very great interest in telephonic matters; and more especially the speech made by the Duke of Marlborough in the House of Lords. But let us see what their statements are. They seem to be founded principally on one thing: that telephone service abroad can be done for very little. I think that Mr. Provand, in his letter, says it can be done for something like £4. 8s. 10d. But when you come to go into that, what do you find? They compare us with Norway and Sweden, where the low rates are. But what possible comparison, except a very misleading one, can there be between places like Norway and Sweden, or towns like Christiania and Stockholm, and cities like London, Manchester, Liverpool, and Glasgow? But when you go into the matter a little further, what do you find beyond that? In the construction of the lines in Norway and Sweden (and a very large amount of the construction account is for the poles for carrying the wires), the poles are on the spot; whereas we have to bear the cost of bringing them over here and distributing them to the various places where they are required. Take what is more important still, namely, the cost of labour in those countries relatively to what it is here, and there is no comparison. Again, telephone companies there are not subjected to a tax of 10 per cent. on their gross income, as we are. We have to pay that. Moreover, they have to pay nothing for wayleaves in those countries, whilst ours amount to £25,000. These facts are all disregarded. The information given to the public is all on one side of the account, and people are left to find out for themselves these other facts. The Duke of Marlborough in his speech says, "There seemed to be three or four times as many subscribers to telephones as there were in London." Now, let us get at the facts. There are 5,300 subscribers in London, and 7,800 in Paris. Yet the public are told that there are three or four times as many there as there are here. I feel con-

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fident that we shall get more subscribers. But that is a sample of the reckless statements that are made; and they are most misleading. He says, "The charge for a telephone in London is £20 a year, whereas the average charge for one in all the European capitals is £6 a year." Well, we will take an important European capital to begin with—Paris. I find that the charge in Paris used to be £24 a year. The Government there, as you are aware, took possession of the telephone system, and, of course, as they do not want to make a profit out of it, they reduced the cost considerably. What did they reduce it to? To £16; and there is a wide margin between an average of £6 and £16. In the provinces of France the Company charged 400 francs, which is £16; but the State reduced that to 300 francs, or £12, for underground exchange wires, and £8 for overhead exchange wires. But they make the subscribers buy their own apparatus and pay for the overhead wires. All this is left out of the calculation. In Berlin and throughout Germany they make an average charge of £7 10s. But there again there is no 10 per cent. to be paid to the Government. There is no cost for wayleaves. The Government take the standards on to the tops of people's houses, whether they like it or not; and, if they object, they will take those standards down and lay them at the front of their doors. You cannot do things like that here. Portugal is not of much importance, but in Madrid the cost is £12, whilst in St. Petersburg it is £23. 2s. 6d. In Norway and Sweden it is £4. 8s. 10d. There is another little thing that they do not mention with regard to these countries—namely, that they allow a certain number of conversations in the year, and if subscribers exceed that number they have to pay for every extra conversation. You may get cheapness there, but they give you very little for your money. Some kind friend sent me a Liverpool paper yesterday, stating that we ought to take an example from the United States of America, where they worked the lines so cheaply that they could be brought into a poor man's house. Now, in New York, the rate is from £30 to £36, whilst in Boston it is from £19. 5s. to £24. In Chicago it is £25, in Pittsburg £16 to £20, in Washington £12 to £16, according to distance; in New Orleans £19. 15s., and in Philadelphia £24. On the whole, though we are recommended to go to America for an example, it strikes me we have not much to learn there on the score of cheapness. Their rates are higher than ours by a long way. Those gentlemen when they commence competition will find out in good time all these things for themselves; and I think it is better to leave them to do it. Then the question arises, how are we to deal with this competition? I do not intend to go into any details as to this matter. It strikes me that it would be very like one general showing his plan of campaign to another. But there are some things that are obvious. I fancy that we are all agreed upon this, that in this fight we do not intend to relinquish our position. We intend to take the necessary measures to consolidate and strengthen our position, and to keep the field, whatever those measures may be. I am quite sure that that is the true way of dealing with it. There are two other things which are of the utmost importance. One is the economy of working—the reduction of working expenses; and the other, which I ought probably to put first, is the efficiency of the service. As regards the latter you must not suppose that we have been idle. From the day that we took this business in hand the efficiency of the service has engaged our attention. Taking London as the greatest example, what did we find there? A great many of the switchboards were of an antiquated pattern, and were not effective; and the first thing we had to do was to replace them by others of more modern construction. We have done so, there being only two left, which is a pretty big stride to take in six or seven months. The next thing we had to deal with concurrently was the junction wires—the joining of one exchange on to another. One of the great defects of the London system has been the multiplicity of the exchanges. We have made a considerable reduction of them, especially in the City; and we intend as we go on, if possible, to get the whole of the work done in one or two exchanges. These junction wires have been greatly improved and looped, but there are a large number yet to be done. We have done 350 miles with the best possible material and of the most modern character. We have still 1,200 to do, and we are proceeding with the work. Then we found in all the instruments a large number of battery bells which were old fashioned and exploded, and we have had to replace them by modern ones—magnetos. We have done so in the case of 1,700, and we have 350 still to do. Then the shackles on the poles were antiquated. Nobody would dream of using them now, and we had to replace them by cross-arms and insulators, which give an infinitely better service. We have replaced a third. We should have been glad to do more, but it would have involved a serious stoppage to the service, and we have had to do it as well as we could from time to time. As it is, we have had no end of complaints. These changes involve a certain amount of defective communication; and it has been a subject of great gratification to me to find that the vast majority of those complaints were simply owing to defective service arising from the exchanges which were badly appointed. Then the report says:—"The extension of the Company's business during the past year has been very satisfactory, the gross annual rental from exchange, trunk, and private lines having increased from £343,544. 1s. 1d. on the 30th April, 1889 (prior to the amalgamation), to £392,541. 19s. 1d. on the 30th April, 1890, an increase in the year of £48,997. 18s." Then it goes on to say:—"The important trunk lines connecting London with the principal towns in the Lancashire, Yorkshire, and Midland districts were completed as far as Edgware in January last, and the service proved to be perfectly clear and distinct. Some difficulty was then experienced in running the wires through to London, which was not overcome in time to have the connection completed before the issue of this report. The Directors have every confidence that the communication between London and the north will be established by the end of this month. A large number of additional trunk lines connecting various towns in the provinces have also been commenced during the year, many of which have been completed." You have heard that so often that you may be a little incredulous. As stated in the report, we have every confidence that they will be established by the end of the month; but I am very glad to tell you that late last night we absolutely got the telephone office in communication with Manchester, Liverpool, and Birmingham. It is a very small room, but if some of you would like to visit it I shall be glad to see you. Of course, you understand that having been brought in at midnight, it will be scarcely in working condition for the public for a little time. "These trunk lines supply a much-felt public want, and will add greatly to the strength of the Company." That will be one of our props of support in the face of competition. We can now go pretty nearly all over the country. I cannot say what profit there will be from them, because they are just opened; but all the other trunk lines that we have opened throughout the country have been profitable, returning a fair interest on the money expended on them:—"The Directors believe it most important to continue the policy of developing and improving the Company's system, and of giving greater facilities to the public. The capital required for this purpose the Directors propose to raise by the issue of Debenture stock or Preference shares, as may be found best for the interests of the Company." That depends very much on the state of the market at the time; but we ask you to leave the Directors to do the best they can. Then we say in the fifth paragraph:—"The accrued rental for the year ended April 30, 1890, was £364,704. 17s. 5d., an increase of £45,162 over the accrued rentals of the National, United, and Lancashire and Cheshire Companies for the year before the amalgamation. The working expenses for the year ended April 30, 1890, amount to £148,457. 8s. 9d., being 40·7 per cent. on the accrued rental, whilst the working expenses of the three Companies before the amalgamation were 47·7 per cent. This saving of 7 per cent. is owing to reductions of working expenditure rendered possible by the amalgamation." That pretty well speaks for itself. You have had a larger business carried on at practically the cost of carrying on a much smaller one. We only got into office in July last year, and then we had to consider and make out our plans how to effect these savings. We could not go rashly to work, and reduce this and that, without thinking what would be the effect over the whole system. This saving has really been effected in seven months, and next year I have no doubt we shall be able to give you certainly as good a report as this one. We have also had some difficulty with regard to labour as well as the Post-Office. It is the same with almost every trade in the country. The next paragraph says:—"The Directors have taken over the business of the Northern District Telephone Company (Limited), which is now merged in this Company." That was carried out a month ago. What we did then I think was a wise thing. I am quite sure it was a necessary thing for the Northern District Company, and I think we shall find out that it will be an advantageous thing for this Company. There is no doubt that it is an advantage more especially to the large subsidiary companies to be amalgamated with a strong Company like this. We have carried that out with the two large companies—the Lancashire and Cheshire District and the United, merging them into the National. The first thing gained by that is a saving of working expenses. But you acquire a great deal more than that. You have got a promptness and decision on the part of the Board which could not be attained with three Boards to consult. The policy of this Company is to take in the South of England and the Western Counties on the most favourable terms. Then we say, "The Postmaster-General not having given notice to purchase the Company's business under the power reserved by the terms of his licence, is not now entitled to do so for another period of seven years." You are all, I dare say, aware of that. The auditors, Messrs. Welton, Jones and Co., retire and are eligible for re-election. In a Company like this we thought it necessary to send out the proxies. The shareholders are spread over the whole of the Kingdom. In the old National Company a large number of the shareholders were in Scotland and all through the provinces; and it was necessary, we thought, to give them an opportunity of expressing approval or censure of this report. I may as well tell you that we have proxies amounting to 181,788 shares, out of a total of 468,984, which is a substantial indication on the part of those who cannot attend here that they are pretty well satisfied with what the Directors are doing. On the 4th of July I received a letter from an important shareholder, asking a very pertinent question as to what is to be done with the reserve fund; and I rather gather that his view is that the best thing would be to invest it in marketable securities. I have no doubt the gentleman is present, and if I am misrepresenting what he says he will correct me. He is not only a large shareholder in the Company, but he is a man who has had considerable experience in financial matters; and his opinion is justly entitled to very great weight. When he says "marketable securities," I do not think that is the only point to consider. We ought to invest this not only in marketable securities, but in securities in which there is not much fluctuation in price, because it would be rather a serious thing, when we wanted any money, to find that there was a drop of 5 or 2½ per cent. in the value of the investment. You want easily marketable and perfectly safe security, where there is not much fluctuation; and Consols are the best that I know for that. But I cannot see where the policy is of investing money which will not give you more than 3 per cent. and borrowing more money by way of increasing the capital on which you pay 4 per cent. As a matter of fact, this reserve for the time being has been largely employed in buying up the Northern District Company. At the time we carried out that arrangement we found that we could get better terms by giving the old shareholders the option of paying them in our ordinary shares or in sovereigns. They took the latter, and by that means, I think, we got a much better bargain. I have now to move:—

"That the report and accounts be taken as read, be received and adopted, and that a dividend at the rate of 6 per cent. per annum, less income-tax, on the first and second Preference shares, and on the fully-paid ordinary shares of the Company (excluding the 52,100 new ordinary), be paid for the half-year ending April 30th last, making, with the interim dividend already paid, a total dividend of 6 per cent. for the year."

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Dr. AUGUSTUS BROWN thanked the Chairman for his lucid statement of the Company's position, and said he approved of giving an efficient service, though they might receive only a moderate dividend.

Dr. GALE asked why it was that they paid only £10 a year at Plymouth for the telephonic service, and whether the £900.000 odd included the antiquated plant of the United Telephone Company (Limited). He did not think they should treat so lightly, as the Chairman seemed to do, the receiver in carrying on a telephonic exchange. He knew from experience that it was of great practical value.

Mr. J. GARNETT observed that the charge for a service in New York was £30, and it was worse than that of London, and ten times worse than that of Lancashire. The consequence was that the charge was being altered to £49, and the people who were now paying £30 were only too glad to pay the higher figure on account of the better service. People had to pay $2 for a conversation of five minutes between New York and Boston. As to the difference of the cost of the telephone in London and Plymouth he thought there was no ground of comparison. He could buy land in Scotland at a penny per yard, but where could they do so in a city like London? The cost of wayleaves, labour, and everything else was different in the two places.

A SHAREHOLDER suggested whether it would not be advisable to have the rest of the second Preference share capital called up at an early date.

Mr. BIDON said that the reserve fund should be exclusively applied to meet contingencies. Supposing, as happened in the case of the United Telephone Company, their wires were swept away by a heavy snowstorm, what would be their position with regard to replacing the wires? He thought it was far wiser to put the reserve fund into Consols or some other security, than to employ it in the business of the Company. He wished to know whether it would not be better to lower the rates with the view of preventing competition.

Mr. LEAKE thought that in the item of £87,174 expenses, the different items should have been separately set out, showing the Directors' emoluments and so forth.

The CHAIRMAN, in reply, thought that if Dr. Gale would apply to the Company he would be able to ascertain why they charged only £10 at Plymouth for the telephone service. As to the Bell receiver, he was not a technical man, but he had taken the best advice he could get, and he was assured that it could not be made efficient. The £900,000 odd was the amount which the investing public considered to be the value, at the time of the amalgamation, of the assets of the United Telephone Company (Limited). The National Company took over all its property and liabilities. It was perfectly clear that it was not to the Company's interest to call up money on which they had to pay a preferential dividend of 6 per cent., when they could get this capital at 4 per cent. At the same time, there was not one of his colleagues, or of the shareholders, who would wish to disregard any honourable understanding that was come to with respect to raising the rest of the Preference shares. There was a difference of opinion amongst them as to the best way of investing the reserve fund, that was whether it should be invested in outside securities or employed in the Company's business. His idea was that it was better to adopt the latter course. He would refrain, for obvious reasons, from answering the question whether they would reduce the rates. Now that the Post Office had made up its mind not to fight the Company, they might be able to get some existing grievances put right. He did not think it would be advisable to let their competitors know the various items of their expenditure; but if Mr. Leake would call at the office, his curiosity could be satisfied.

Mr. J. S. FORBES, in seconding the resolution, said he was sure, though he had not had an opportunity of ascertaining their views upon it, that his colleagues equally desired with himself that they should not let the occasion of their first meeting of the amalgamated Company pass without adverting to the great services rendered to it by the President, who had made personal sacrifices, not only of time, but of health, in the service of their great corporation. Such an amalgamation as they had effected involved questions of policy, judgment, and justice; and they had had great advantage in these respects from the President. They had also benefited greatly by the presence on the Board of Colonel Jackson, the late President of the National Company, and all the other gentlemen forming the amalgamated Board, who have been content to sacrifice personal feeling to the good of the undertaking. He congratulated the proprietors upon the happy inspiration which brought about the fusion of the Companies on terms equitable to all, and the indirect benefits of which had not yet been realised.

The resolution was then put to the meeting, and carried unanimously.

On the motion of Mr. JAMES GODDARD, seconded by Mr. BEGG, the auditors, Messrs. Welton, Jones, and Co., were re-appointed.

A vote of thanks having been passed to the Chairman and Directors, the proceedings terminated.

Elmore's Wire Manufacturing Company (Limited).

The first general meeting of the above Company was held on Monday, July 14th, 1890, at the City Terminus Hotel, Cannon-street; Mr. George Smith presiding.

The SECRETARY (Mr. J. Shurmer) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, in the absence of your chairman, Sir John Morris, who is at present out of town, he has asked me to preside at this first meeting of the Elmore's Wire Manufacturing Company. The meeting to-day, as you know, is a formal statutory meeting, without report and without accounts. You will, however, wish to know what the Directors have been doing during the four months of the Company's existence, and we are happy to tell you what is the present position of the Company's affairs. First, as to the subscribed capital. Notwithstanding the adverse condition of the financial world at the time of the launching of this Company, about 500 applicants subscribed for the shares, and an ample allotment was made to carry on the business of the Company. As to our relations with the Stock Exchange, application has been made to it for a quotation and a settlement; and upon the shareholders agreeing to the proposed alteration in the articles required by the Stock Exchange Committee, we shall doubtless have our request granted. A special meeting at the close of this one will be held to pass a resolution for that purpose. Then as to the land the Company has acquired. Twelve acres of freehold land have been secured adjacent to the parent Company's works at Haigh Park, Leeds, and manufacturing buildings are being erected thereon under the responsible supervision and control of our managers. Orders have been given for plant, and these will be followed up judiciously till we complete the factories and set them to work, which we anticipate we shall do before the close of this year. The Company's arrangements for its works have been influenced by the consideration of the many advantages of having them contiguous to those of the parent Company. We can then share with that Company the services of Messrs. Elmore, and so minimise an important item of our working expenses, whilst we shall secure the presence of these gentlemen always at hand. The policy which the Directors have elected to follow has been to work with, rather than against, the wire manufacturing trade; and we are happy to say that a very substantial group of Birmingham wire drawers have offered to take the whole of our output of spirals for 1891, with prospective arrangements for continuing the agreement, and that at a price which will yield us satisfactory results. The advantages of such an arrangement are many and obvious. First we can at once secure an established trade for all that we can make without having to create one for ourselves; secondly, we enlist the interested co-operation of some of the most important manufacturers in the country, instead of having them for our rivals; thirdly, we avoid bad debts, the firms in question being of the highest standing; and fourthly, we are released from capital expenditure for wire drawing, which will enable us to lay down more depositing plant, and so simplify and increase our business. It only remains for me to notice an agreement which we are entering into for carrying out the above offer. The terms have been approved, and the agreements themselves will shortly be executed and exchanged by the parties concerned. The Directors, therefore, feel that they may congratulate the shareholders of the Elmore Wire Manufacturing Company upon the prospects which are before them. Those shareholders who may wish to see examples of our manufactures by this depositing process may see them exhibited at 56, Queen Victoria-street, and they will do well to inspect them.

The SECRETARY then read the notice convening the extraordinary general meeting, held for the purpose of passing the following resolution:—

"The Company may make contracts with any of the Directors upon such terms as the Directors shall think fit, and a Director shall not by reason of the fiduciary relation subsisting between him and the Company be accountable for any profits made by him in respect of any such contract; nor, subject to the following proviso, in respect of any other contract made with the Company in the profits of which he participates, or in which he is otherwise interested, provided that the fact of his being so interested therein, and the nature of his interest, be fully and fairly disclosed by him at the meeting of the Directors at which the contract is determined on, if his interest then exists, or in any other case at the first meeting of Directors after the acquisition of his interest; but in the case of contracts with companies or firms of which any Director of this Company is a member, it shall not be necessary to disclose more than the fact of such membership, provided always that in no case shall such Director so interested vote, or, if he does vote, his vote shall not be counted."

The SOLICITOR (Mr. Hollams) said that the only change made in the existing regulations by this resolution was the last few words, "provided always that in no case shall such Director so interested vote, or, if he does vote, his vote shall not be counted." This restriction was required by the Stock Exchange. He confessed that he did not know how the clause had been omitted in the Articles as originally prepared.

The CHAIRMAN formally moved, and Mr. CARSON seconded, the resolution, which was agreed to *nem. con.*; and the proceedings terminated.

The Direct United States Cable Company (Limited).

The following is the Report of the Directors for the six months ended June 30, 1890, to be presented at the twenty-sixth ordinary general meeting of the Company, to be held at Winchester House, E.C., on Friday, the 25th inst., at 2 p.m.:—

The half-year's revenue (subject to revision on decision of the case mentioned below) after deducting out-payments, amounted to £40,017 1s. 0d., against £39,626. 8s. 5d. (after similar deductions), for the corresponding period of 1889, being a difference of £390. 12s. 7d. in favour of the half-year under review.

The working and other expenses for the same period, including income-tax, but exclusive of cost of repairs of cables, amounted to £17,616. 5s. 8d., leaving a balance of £22,400. 15s. 4d. as the net profit of the half-year, making with £8,317. 19s. 4d. brought forward from the previous half-year a total of £30,718. 14s. 8d. For the corresponding half-year of 1889 the working expenses and other payments amounted to £16,676. 3s. 9d.

Three quarterly interim dividends of 3s. 6d. each per share, amounting to £31,872 15s., have been declared and paid during the financial year, and a final payment of 3s. 6d. per share is now proposed, making, with the three interim dividends, 3½ per cent. for the year, being a total distribution of £42,497. An amount of £8,502. 4s. 5d. has been transferred to the reserve fund account, which now stands at £250,000, and the balance of £968. 0s. 3d. on the revenue account is proposed to be carried forward.

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During the earlier portion of the past half-year the traffic showed a slight diminution as compared with the corresponding period of the previous year, but lately an increase has taken place which it is hoped may be progressive.

The Anglo-American Company having in January last opened offices of its own in New York, the expense of the office at 40, Broadway, in that city, previously maintained as a joint office, is now entirely borne by this Company, accounting for the increase in the expenses during the past half-year. The maintenance of an independent office in New York is regarded as necessary. A station has been opened by this Company at 40, Hope-street, Glasgow. These additional facilities are already producing beneficial results.

A break occurred in the short section of cable on January 19th last, about 122 knots from Halifax, which was repaired on March 30th. On April 10th a fault was removed from the shore end of the same cable near Rye Beach. On May 26th a break occurred in the main cable, which was promptly repaired on the 29th. The breaks in the cables were found to have been caused by vessels' anchors. The repairing operations have cost £4,919. 13s. 5d., which has been debited to the reserve fund account, as heretofore.

The interests of the Company were represented at the International Telegraphic Conference recently held in Paris. In the case of the Anglo-American Telegraph Company *v.* Cie. Française du Télégraphe de Paris à New York, the Appeal to the Council of State, mentioned in the Report to June 30, 1889, is still pending.

Pursuant to the provisions of the Articles of Association, two of the Directors, viz., Charles Meara, Esq., and E. M. Underdown, Esq., Q.C., retire by rotation, and being eligible offer themselves for re-election. Mr. John G. Griffiths, F.C.A., and Mr. John Sawyer, F.C.A., the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

United River Plate Telephone Company (Limited).

The following is the Report of the Directors for the year ending the 31st March last, to be presented to the shareholders at the fourth ordinary general meeting, to be held at Winchester House, E.C., on Tuesday, the 22nd inst., at 12 o'clock :—

After paying all working expenses abroad, debenture interest, London and other charges, there is a profit of £34,198. 6s. 5d., from which has to be deducted the sum of £22,334. 17s. 1d. for loss on exchange, leaving a net profit of £11,863. 9s. 4d., increased by the balance of £1,210. 7s. 2d. brought forward from the previous year, to £13,073. 16s. 6d. Out of this, an interim dividend of 2 per cent., or £5,800, was paid in January last ; and the Directors recommend that out of the remaining balance of £7,273. 16s. 6d. a further dividend of 1 per cent., or 1s. per share, free of income-tax, be now paid, which absorbs £2,900 ; that £2,000 be placed to the depreciation and renewal fund, thereby increasing it to £9,000 ; and that the balance of £2,373. 16s. 6d. be carried forward to the credit of profit and loss account for the current year.

As shown in the balance-sheet accompanying the Report, the capital expenditure during the year amounted to £12,772. 8s. 0d. as against £35,070. 2s. 11d. in the previous twelve months.

The shareholders will see from the profit and loss account, that the business of the Company has largely increased during the past year, the gross receipts having been £108,612. 2s. 7d., as compared with £81,866. 2s. 4d. in the year before. Such a development of business has neccessarily increased the working expenses in the River Plate, and the continued depreciation in the currency there has naturally given rise to a necessity for higher wages. In spite of these difficulties, the result of the Company's working would have been very satisfactory but for the serious increase (more especially during the second half-year) in the loss on exchange, which amounted to £22,334. 17s. 1d., as against £14,689. 6s. 8d. in the previous year, the net profits having been thereby so reduced as to make it impossible for the Directors to recommend so high a dividend as last year. But to meet this loss on exchange to some extent, the Directors raised the rates of subscription on the 1st January last, and they are glad to say that the change has been carried out successfully.

The shareholders will remember that the Directors were authorised at an extraordinary general meeting, held on the 9th January this year, to issue Debenture Stock and to convert the then existing 7 per cent. Debentures ; and the Directors are glad to report that out of £100,000 7 per cent. Debentures £97,000 have been converted into 5 per cent. Debenture Stock, and that £29,000 of the same Stock, offered to the shareholders, was largely over subscribed.

Under the Articles of Association the Right Hon. Lord Thurlow and Mr. Frederick Green retire by rotation at this meeting, but, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper Bros. and Co., also retire, but offer themselves for re-election.

Crompton and Co. (Limited).

The following is the second report of the Directors, to be presented at the annual general meeting of the shareholders, to be held at the Cannon-street Hotel, E.C., on Monday, the 21st inst., at 2:30 p.m. :—

The net profits for the year amount to £10,610. 1s. 7d., and after payment of the interim dividend last December, and providing for Debenture interest and other payments, set out in the accounts, there remains a balance of £6,030. 6s. 0d., from which the Directors propose, after setting aside a sum of £500 as a provision for doubtful debts and contingencies, to declare the usual dividend of 7 per cent. per annum upon the Preference shares, and 5 per cent. per annum upon the ordinary shares, carrying the balance forward.

The business of the Company has greatly increased, necessitating considerable extension of the works and large additions to plant. The contract for the public lighting of Chelmsford has been carried out, and the result has given great satisfaction in the town. It is hoped that private consumers will now apply for the light in sufficient numbers to make the contract a profitable one. The installation has cost more than the original estimate, largely in consequence of unexpected and difficult requirements of the Board of Trade.

Very important contracts have been arranged with several of the electric supply companies in London, the principal feature of which is that this Company receives a fixed profit upon the actual cost of the works ; and large orders are also in hand for other companies and firms, the prospects of the present year being in consequence very good.

It is with the greatest regret that the Directors have to record the loss by death, in October last, of Viscount Torrington, Chairman of the Company. In accordance with the Articles of Association, Sir Charles Grant retires from the Board of Directors by rotation, but offers himself for re-election. The auditors, Messrs. J. H. Duncan and Co., also offer themselves for re-election.

NEW COMPANIES REGISTERED.

BLACKMAN VENTILATING COMPANY (LIMITED).—Registered by Gadsden and Treherne, 28, Bedford-row, London, W.C., with a capital of £75,000 in £1 shares. Objects: To purchase from the Blackman Air Propeller Ventilating Company (Limited), and the liquidators thereof, all the business, letters patent of every description ; to acquire the business, letters patent, and inventions of Isaac D. Smead, of Toledo, Ohio, U.S.A.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
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WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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JOHN BENNET LAWES AND CO. (LIMITED).—Registered by Markby, Stewart and Co., 57, Coleman-street, E.C., with a capital of £80,000 in £100 shares. Object: To acquire the business of a chemical manufacturer now carried on by Sir John Bennet Lawes, at 29, Mincing-lane, and the Atlas Works, Millwall.

GRANGEMOUTH GAS COMPANY (LIMITED).—This Company has been registered by Mr. W. M. Anderson, Grangemouth, with a capital of £10.000 in 10,000 shares of £1, to carry on and continue the business of making and supplying gas for providing light, heat, or motive-power within the burgh of Grangemouth and the immediate neighbourhood; to carry on the business of an electric light company, and the business of electricians, mechanical engineers, &c.

BLAKE AND KNOWLES STEAM PUMP WORKS (LIMITED).—Registered by Ashurst, Morris, Crisp, and Co., 6, Old Jewry, E.C., with a capital of £300,000 in £10 shares. Object: to carry into effect an agreement with the George F. Blake Manufacturing Company, of Massachusetts, and the stockholders thereof, which is detailed in Clause 3 of the Articles of Association; to carry on the business of manufacturers of, and contractors for, the sale, letting on hire, erection, repair, maintenance and renewal of steam pumping and other machinery; to carry on business as mechanical, electrical, metallurgical and chemical engineers, iron and other founders in all branches.

VICTORIA TORPEDO COMPANY (LIMITED).—Objects: To acquire letters patent granted to George Read Murphy, electrician, of 9, Fenchurch-avenue, London, for improvements in means and mechanism for propelling, controlling, steering, and exploding torpedoes, adopting therefor an agreement of July 2, made with the said patentee, the particulars of which are not specified in the Articles of Association. Capital £16,000, in £1 shares. Registered, without special articles, July 2, by C. P. Pritchard, Marshall, and Nunn, solicitors, 27, Gracechurch-street, London.

SHAW ENGINEERING COMPANY (LIMITED).—Registered by Robinson, Preston and Stow, 35, Lincoln's-inn-fields, W.C., with a capital of £16,000 in £1 shares. Object: To carry on the business of mechanical engineers, metal founders, &c., at Canon's Marsh, Bristol, in accordance with an agreement, made June 27th, between Edward Shaw and George John Harcourt of the one part and John Bicknell, on behalf of the company, of the other part.

SHERRIN ELECTRIC POWER GENERATOR COMPANY (LIMITED).—Registered by Johnson, 5, Austin-friars, E.C., with a capital of £100,000, in £1 shares. Objects: To adopt an agreement, made July 2, between J. Sherrin, J. V. Sherrin, T. Richardson, and H. F. Woodgate, of the one part, and G. M Canham, on behalf of this Company, of the other part. There shall not be less than three nor more than seven Directors. The first shall be appointed by the subscribers to the Memorandum of Association, with the proviso that one be nominated by J. Sherrin, J. V. Sherrin, T. Richardson, and H. F. Woodgate. Qualification, 100 shares. Remuneration, £2,000, divisible.

SMITHY BRIDGE IRON AND STEEL WORKS (LIMITED).—Objects: To acquire the business of the Paragon Works (Limited), mechanical engineers, and founders and workers in metal, at Smithy Bridge, near Rochdale, and carry on the same and others analogous thereto. Capital, £32,000, in £10 shares, of which 1,600 are 8 per cent. Cumulative Preference shares.

CITY NOTES, &c.

ALLGEMEINE ELEKTRICITATS GESELLSCHAFT.—The resolution for the increase of the capital of this Company which is to be put before the shareholders at the meeting on the 28th inst., is intended to enable it to carry out some new undertakings, the most important of which is the addition to its business of an electric traction branch. A horse tramway in Halle has already passed into the hands of the Company, and a beginning will be made here and in two other large towns. It is also intended, we understand, to acquire, in conjunction with Messrs. Siemens and Halske, an interest in the Tudor accumulator factory of Messrs. Einbeck and Müller, at Hagen.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 11th amounted to £4,734.

AMALGAMATIONS IN AMERICA.—The *Financial News* is responsible for the following:—"A deal involving upwards of $5,000,000 and including a transfer of a controlling interest in the Badger Electric Light Company, the Edison Light Company, and the Cream City and Milwaukee Street Car Companies, is said in the American papers to have been practically consummated. The purchaser is the so-called Villard syndicate, including Henry Villard, and Ryan, the Pittsburgh capitalist. But Milwaukee capitalists will still retain an interest in each of the corporations, although there is a complete change of owners in the Badger Electric Light plant. The purchasers outside of the Villard syndicate are the same Milwaukee men who are interested in the Edison Electric Light plant now being built."

COMMERCIAL AND INDUSTRIAL FINANCE.—Last week we published some extracts from the *Financial News* giving interesting figures showing the appreciation in value of the shares of various Electrical Companies, together with the sums which had been returned to the shareholders in dividends. Our contemporary yesterday returned to the subject, and gave similar figures with regard to a number of companies which, although not quoted on the London Stock Exchange, are freely dealt in on the provincial markets, and are quoted in their weekly lists; and we again extract information relating to companies connected with the electrical profession:—

—	Par value.	Present price.	Capital subscribed.	Market value.	Returned in dividends.
			£	£	£
Birmingham Small Arms & Metal	5	15	203,150	609,450	247,780
Braby (F.) and Co.	10	11¼	25,000	28,125	46,625
Evered and Co. Pref.	10	14⅜	67,440	99,474	24,950
Do.	7	9⅛	68,264	92,644	25,575
Liverpool Electric Supply	5	5⅛	50,000	51,250	16,500
Do.	2	2¼	60,000	63,750	12,000
Nettlefolds	10	24½	420,000	1,029,000	195,300
Do. 5 per cent. Pref.	10	13¼	210,000	278,250	94,500
Do. Def. Profit Debs.	100	101	80,000	80,800	38,000

DIRECT UNITED STATES CABLE COMPANY.—The Board of Directors of this Company have resolved to recommend a final dividend of 3s. 6d. per share, free of income-tax, such dividend to be payable on and after the 26th inst., making, with the interim dividends already paid, 3½ per cent. for the year ending 30th June last, carrying forward £968. 0s. 3d., after having transferred to the reserve fund account £8,502. 14s. 5d., making it up to £250,000. The transfer books of the Company will be closed from the 11th to the 25th July, both days inclusive.

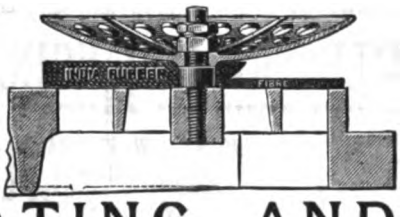
EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY.—The Directors of this Company have decided to recommend to the meeting of the shareholders, to be held on the 28th inst., that a dividend at the rate of 7 per cent. per annum on the A shares for the half-year ending June 30, 1890, (making 7 per cent. for the year), and a further dividend of 4 per cent., in completion of payment of arrears of Cumulative Preference Dividend for the year ending June 30, 1884, and a further dividend of 4 per cent. in respect of arrears of Cumulative Preference Dividend for the year ending June 30, 1885, free of income-tax, be distributed in accordance with the provisions of Clause 87 of the Articles of Association.

GLOBE TELEGRAPH AND TRUST COMPANY.—The Directors of this Company recommend, subject to audit, the payment of a final dividend of 3s. per share on the Preference shares, less income-tax, and of 4s. 3d. on the ordinary shares, income-tax having been already deducted, making, with previous payments, a total dividend for the year of 6 per cent. on the Preference shares, and of 5 per cent. on the ordinary shares, as against 4⅝ per cent. for the preceding year, and carrying forward £108. The meeting of shareholders takes place on the 29th inst. at Winchester House, E.C., at 1 o'clock.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 11, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,644.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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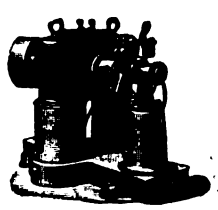
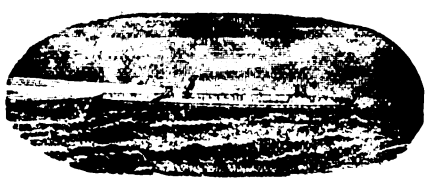
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 9.	Price Wednesday, July 16.	Rate per Cent. Yielded.	Dividend Due.	Business Done during Week ending July 16. Highest.	Lowest
£			**TELEGRAPHS.**			£ s. d.			
1,381,330	Stock	12/6	Anglo-American	50 51	50 51	5 7 10	Jan., Apr., July, Oct	..	..
2,809,310	Stock	25/0	Do. Preferred	85½ 86½	86 87	5 14 11	" "	87	86
2,809,310	Stock	..	Do. Deferred	14 14½	14¼ 14⅜	..	..	14⅜	13⅞
25,000	£100	4%	African Direct, 4 per Cent. Debentures	97 100	97 100	4 0 0	January and July ..	98½	98
130,000	10	3/0	Brazilian Submarine	11½ 12⅛	11½ 12⅛	4 16 0	Mar., June, Oct., Dec.	11⅜	11⅛
69,200	100	5%	Do. 5 per Cent. Bonds	102 104	102 104	4 16 2	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103 107	103 107	4 13 6	June and December	..	..
..	$100	..	Commercial Cables	103 105	103 106	..	..	103⅜	103⅛
16,000	£10	9/0	Cuba Submarine	12½ 12⅝	12⅝ 13½	6 15 10	February and August	12⅝	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	17⅛	..
12,981	5	2/4⅛	Direct Spanish (£4 paid)	3½ 3⅝	3½ 3⅝	..	March & September	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10⅛ 10⅜	10 10½	6 16 7	Jan., Apr., July, Oct	10⅛	10⅛
400,000	10	2/6	Eastern	14⅛ 14⅜	14 14⅛	4 11 3	" "	14⅛	13⅞
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15⅛	3 17 5	" "	..	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106 109	10[illegible] 109	3 13 5	May and November	107	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108 111	1[illegible]8 111	4 10 1	February & August	109½	..
250,000	10	6/6	Eastern Extension xd	14½ 14⅝	13⅞ 14⅛	4 19 1	Jan., Apr., July, Oct.	14⅛	13⅞
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101 103	101 103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Aust'n. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	103⅜	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor Deb., 1900	100 103	100 103	4 17 1	" "	101⅛	..
180,227	10	2/0	Globe Telegraph and Trust	9 9½	9⅛ 9⅜	5 6 8	Jan., Apr., July, Oct.	9½	9
180,042	10	6%	Do. 6 per Cent. Preference	15⅛ 15⅝	15⅛ 15⅝	3 18 1	" "	15⅞	15
150,000	10	5/0	Great Northern	15⅝ 16⅛	15⅝ 16⅛	4 12 4	Jan., April, and July	15⅝	..
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100 103	100 103	4 17 1	January and July ..	101	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	37 39	37 39	6 8 2	April and October	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞ 8⅛	7⅞ 8⅛	6 1 3	April and October	7⅛	..
3,881	£100 Cert.	..	Submarine Cables Trust	112 116	112 116	..	" "	..	..
15,609	£10	5%	West African xd	9⅜ 10⅛	9 10	5 0 0	.. ..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	100⅛	99⅛
30,000	10	2/0	West Coast of America	6 6½	6 6½	..	January and July ..	6½	..
150,000	100	8%	Do. Debentures 8%	108 112	106 112	7 2 10	June and December	108½	107½
88,321	10	Nil.	West India and Panama	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅝	..
34,563	10	6/0	Do. 1st Preference 6%	11 11½	11 11½	5 4 4	April and October	11½	11⅜
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12⅜ 13⅛	12⅜ 13⅛	..	..	..	..
64,572	15	6/0	Western and Brazilian	9⅞ 10⅛	10 10⅛	5 14 4	May and November	10⅛	10⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	..	..	6⅞	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3⅛ 4	3⅛ 4	..	..	4	3⅞
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106 109	106 109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104 107	104 107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99 101	99 101	5 18 10	March & September	..	..
			TELEPHONES.						
224,350	14/0	0/5⅛	Consolidated Telephone Const. and Maintenance	⅛ ⅜	⅛ ⅜	..	Yearly	⅜	..
220,000	£1	3%	Oriental (11s. paid)	⅛ ⅜	⅛ ⅜	4 8 3	Yearly	..	..
386,875	5	3/0	National xd	5⅛ 5⅜	5⅛ 5⅜	..	June and December	5⅜	5⅛
49,825	5	1/4½	Do. New	5½ 5⅝	5¼ 5⅜	..	..	5⅛	5⅜
15,000	10	..	Do. 6 per Cent. Cumulative 1st Pref. xd	12½ 13	12½ 12⅝	4 14 1	June and December	..	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Pref. xd	10⅛ 10⅜	10⅛ 10⅜	5 11 7	" "	..	..
209,750	1	..	South of England, Ordinary	⅛ ⅜	⅛ ⅜	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	2½ 3½	2⅝ 3½	..	..	..	..
55,000	5	2/0	United River Plate	4½ 5	4½ 4⅝	..	January and July ..	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	2½ 2⅝	1⅞ 2⅛	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4½ 5	4½ 4⅝	..	..	4½	..
42,853	5	..	Westminster Electric Supply	1⅝ 2	1⅝ 1⅞	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	1⅞ 2⅛	1⅞ 2	..	..	..	..
63,416	2	1/2	Do. Preference	1⅝ 1⅞	1⅝ 1⅞	..	..	..	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5½ 5⅝	5½ 5⅝	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
400,000	10	..	Electric Construction	9⅞ 10⅛	7⅛ 8	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5⅛ 6	5⅞ 6⅛	..	..	5⅛	5⅛
20,000	5	..	Fowler-Waring Cables	2 2½	2 2⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works. xd	19 20	19⅛ 19⅜	5 2 7	February & August	19⅞	19⅜
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5⅛ 5⅜	5 5⅛	..	..	5⅜	5⅛
37,350	12	36/0	Telegraph Construction and Maintenance xd	44 46	43 45	5 6 8	March and July	44⅛	44
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 102	100 102	4 18 0	..	..	..





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NOTES.

The occasions on which it is necessary that political questions need appear in these columns are happily rare, and we did not intend that the second leading article of last week should be one of these; but we can neither refuse to allow Mr. Fawcus to offer his criticisms, nor can we let his letter pass in silence. We are utterly opposed to Socialism. We hold that individual enterprise is the *régime* under which this country has attained her position and under which progress is to be made. The position of the Post Office is no more one of State Socialism than is the War Office. The State purchase of the telegraphs has proved to be a great success because telegraphic communication necessitates a centre. We look forward to the purchase of the telephones because a centre, or an organised system of centres, is yet more necessary than in the case of the telegraphs. The subscribers of the South of England Telephone Company are most anxious to be connected with the National Company's system, but co-operation and organisation are prevented by trade rivalry or financial complications. If in the hands of the Post Office the engineering and instrumental work of the telephones is done as well as that of the telegraphs, English telephony will be as unrivalled as is English telegraphy. Postal communication should be carried on, as is universally the case, by the Government; but not as a source of revenue. The telegraphs will, probably, never repay the purchase price, and press telegrams are carried at a large loss, which constitutes a Government subsidy to the newspapers. The Chamberlain Electric Light Act is on another footing. The supply of electricity is a commercial undertaking, and should, therefore, be carried out by private enterprise.

Birmingham is to be congratulated on the thorough style in which the Bristol-road electric tramway has been carried out. The work has been done on a very different scale to that of the numerous experiments which have contributed so little credit to traction by accumulators in this country. Many of these, no doubt, have been restricted to the experimental stage through lack of capital, and the work too often has been carried out with make-shift appliances in a merely experimental manner. In more than one case the designs and general ideas have been good, and capable electricians have been employed to carry them out. In some instances the history of the failures has been recorded; in others, the struggles have been forgotten. The idea of running tramways by a syndicate or a company at so much a mile for the tramway company is one which does not commend itself to a contractor. At the best it affords on the one hand a somewhat remote chance of recouping the cost of an extensive experiment; and, on the other, it enables the Directors of the tramway company to watch, without any pecuniary risk, the result of the trials. Enough has been done in the way of experiment to show to engineers that electric traction by accumulators is, under proper conditions, a practical possibility; but nothing has yet been done to convince the public that the system is remunerative. No respectable balance sheet has been published from actual costs; but we are persuaded that it merely needs a plant of the thorough character of the one at Birmingham, and designed and carried out by a competent staff of experienced and qualified engineers, to prove that the system is sound, and that the failures of the past have been due to the lack of that completeness which is to be found at the Bournbrook terminus of the new line. The Birmingham Electric Tramway has a curve of 40 feet radius on a gradient of 1 in 28, and a gradient for about 200 yards of 1 in 32. Heavy gradients are the most serious obstacle to the storage system of electric traction; and we hope that as the rest of the line is easy no difficulties will arise on this score.

Mr. Verity calls attention, in a letter which was crowded out last week owing to late Edinburgh news, to the multiplicity of rules under which contractors for wiring have to work, and suggests that adherence to the regulations of the Institution of Electrical Engineers should be sufficient. It has been said that these were never intended to supersede specifications; but are not specifications the exception rather than the rule? In the majority of cases of private house-wiring the owner asks a contractor to give an estimate for "putting in the electric light;" the contractor being either properly qualified to carry out the work, or merely the builder who is doing general repairs, or perhaps a sanitary "engineer," *i.e.*, a plumber and bellhanger. It is not fair to say that builders should not be allowed to wire houses. We know of one now in progress, where the work is being carried out by the electrical staff of a well-known builder in a most thorough and neat style; while the wiring of well-known electrical firms is sometimes a pitiable bungle. The contractor, if he is a qualified electrical engineer, will generally send some kind of statement of what he proposes to do, with his estimate; and this is often the only specification that appears. If the house is insured in several different fire offices, the contractor has no choice but to work

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in accordance with their respective rules, or rather in accordance with what his experience tells him will be the interpretation of these rules by the different inspectors, and in accordance with the regulations of the supply company, or companies, in whose district the house is situated. As far as we are aware, there is no absolute contradiction among them. One set may dictate a higher insulation resistance than the others, in which case the latter may be ignored. Another may call for earthenware tubes for passing through walls. These must then be provided, although no other rules demand them. A quarter of an hour's work would settle the critical demands of as many different sets of regulations as are likely to be imposed in any one case.

WHEN a consulting engineer is employed to give a complete specification of the wiring of a house, we do not see that he should be expected to extract the maximum demands from all the rules, and embody them in his specification. It should be sufficient for him to specify his wishes on all points that do not appear in the rules, and to add that the work is to be carried out in accordance with the rules of the Institution of Electrical Engineers, of the various fire offices, and of the various supply companies concerned. The real trouble lies in the arbitrary interpretation of the rules by the different inspectors or surveyors. That the rules should be flexible has been conceded over and over again; the rapid growth of the industry necessitates it. An inspector is within his rights, we believe, in condemning the old-fashioned wooden lampholders and switches that were common six years ago; but he has no right whatever to assert that the onus of replacing them by modern fittings must be borne by the contractor who supplied them. Careful inspection by surveyors from the insurance offices, though often causing unnecessary annoyance, has been of immense service. They have done their work thoroughly, in the face of considerable opposition, and their duty has often been unpleasant. We feel confident that the insurance offices will suffer if they cause the electrical industry to suffer; and as the effect will be felt most by the office which offends most, while it is evenly spread over the electrical trade, there is every reason to suppose that the matter will soon right itself.

THE loss of energy due to hysteresis and FOUCAULT currents are points in the theory of transformers which are still very obscure. The separation of these heating effects from each other, and the influence which the frequency of the current and the temperature of the core have upon their magnitude, are important matters, to which little attention has yet been given. The analytical method of studying the action of transformers is unsatisfactory, since it depends on the erroneous assumptions that the coefficients of induction are constant quantities, and that the waves of potential follow a simple sine law; and it is thus highly important to obtain the curves showing the actual values of the electromotive force and current at different parts of the alterna tion. Unfortunately, the experimental difficulties in the way are considerable. Not only is the apparatus required very complex, but the uncertainty due to leakage and other sources of error is great enough to cast doubt on most of the curves hitherto published.

THE shape of the potential curves obtained with alternators was one of the many important subjects alluded to at the Institute of Electrical Engineers, in connection with Mr. MORDEY'S paper on "Alternate-Current Working;" and at the end of the discussion a method of determining the curves was described, and it was announced that some striking results had been obtained with the Mordey Alternator. As far as we are aware, these results have, however, never been printed, and as yet the best work which has appeared in connection with this subject, has been carried out at the Cornell University. The first portion of this work, due to Prof. RYAN, was published by us in January of this year. A supplementary Paper by Messrs. HUMPHREY and POWELL appeared in our issue of last week, while in another column we reproduce an additional contribution by Prof. RYAN. The success which has attended these efforts appears to have been due in great measure to the employment of an electrometer of novel construction.

THE work of Messrs. HUMPHREY and POWELL had reference to a transformer of considerable size and high efficiency, the object of the experiments being to determine the influence of FOUCAULT currents on the shape of the curves and on the efficiency of conversion. Prof. RYAN, in his second Paper, is only concerned with the connection between the temperature of the core and the loss of energy from eddy currents; and his transformer, the construction of which was determined by the phenomenon which had to be investigated, was very small and badly designed from a practical point of view, its efficiency never exceeding 30 per cent. The Papers are of interest, since they indicate two distinct methods of separating the heat waste arising from hysteresis and FOUCAULT currents. Hitherto, the best method of separation has been to vary the frequency of the current. Prof. RYAN, however, accomplishes the same object by varying the temperature of the core, and also by comparing the curves obtained from EWING'S hysteresis experiments with those deduced from the current and magnetisation curves.

PROBABLY not one student in twenty who has grasped the idea of OHM'S law has ever doubted its absolute truth; there seems to be such a simple completeness about it. But MAXWELL has asserted that it is a purely empirical assumption, and relies on experimental evidence alone. The work of Prof. CHRYSTAL, in 1876, who determined its truth to a degree of accuracy which is rarely attained in any physical measurements, has appeared to some to be as unnecessary as a minute experimental investigation of the accuracy of the parallelogram of forces. The point lies in the question, is the resistance of a conductor constant for all currents, *apart from considerations of temperature or magnetisation or other indirect effects?* If a wire has a resistance of one ohm when two or three hundredths of an ampere are passed through it, will it still remain one ohm when a pressure of several hundred volts forces a heavy current through it? Will the great density of the current break down

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any part of the structure of the conductor, or alter its conductive properties? That alone can be settled by experiment. Dr. OLIVER LODGE has sent us an interesting letter on this subject from Prof. CHRYSTAL to Prof. FITZGERALD, which will be found in another column. In connection with this subject we may draw attention to a letter which will be found in our columns from Prof. SILVANUS THOMPSON, who, while clearing one of the issues raised by Professors LODGE and CHRYSTAL, raises another which can scarcely be said to make the subject more simple than before.

AT the close of the strawberry season and the commencement of a little summer weather, a short article in *L'Electricien* on "Revivification Électrique des limes et fraises" seemed to be very appropriate, but on further examination of the paragraph, assisted by our dictionary, we discovered that "limes et fraises," in the present case, mean files and rasps. The method of recutting files, saws, scythes, and other tools by acid, generally a secret mixture, has been the subject of many a query in the *English Mechanic*. It is obvious that where acids are used to dissolve metal, the result may be hastened or controlled by an electric current, as in the etching process, described in another column. In the present case, according to *Le Génie Civil*, where a more complete description is given, the files are suspended in acidulated water, with carbon plates. The tools are connected as anodes. The water is decomposed by the current, and it is suggested that the oxygen goes "energiquement" to the bottom of the teeth which are attacked, the hydrogen forming little bubbles on all the projecting points which thus become protected. Chrome steel is said to give particularly good results under this treatment. The process occupies about 20 minutes. We are somewhat sceptical about the obliging way in which the oxygen goes to work, nor do we see how both oxygen and hydrogen are given off at the same pole, but no doubt the protection of the bubbles of hydrogen constitutes an improvement on the old and doubtful idea of recutting by acid alone.

Paddington.—The Provisional Order granted to the Metropolitan Electric Supply Company for lighting this parish has been confirmed.

The Henry.—The American Institute of Electrical Engineers has passed a resolution, in very formal phraseology, recommending that the unit of self-induction should be called a "henry."

The Electrical Standardising, Testing and Training Institution.—The new session of this Institution, which is under the direction of Mr. H. E. Harrison, B.Sc., begins on Wednesday, September 17th next.

Discovery of Platinum in Mexico.—It is reported that Mr. Flavio Lobato, a well-known mining engineer and analytical chemist, has discovered platinum in some ores from the Las Yedras mines in the State of Sinaloa.

Electrical Treatment of Hæmorrhage.—Dr. Eugen Boér has successfully applied faradisation to cases of profuse internal hæmorrhage, applying the negative electrode to the affected part, the positive pole being pressed against the skin.

The Working Efficiency of Secondary Cells.—We are informed that it has been arranged that the discussion on this valuable Paper will be continued when the meetings of the Institution of Electrical Engineers are resumed in November.

Restoration of Telegraphic Communication with Australia.—Telegraphic communication with Australia, which it will be remembered was interrupted by an earthquake, was restored on the 20th inst.

Paisley.—At the monthly meeting of the Town Council on the 17th inst. it was agreed to oppose the application by the Scottish House-to-House Electricity Company for a Provisional Order to supply electricity in the burgh for public and private purposes.

Tivoli.—The Central Station (which it is hoped will be finished in August) is to contain nine Girard turbines, six of 350 horse-power and three of 50, and nine alternators, six giving 45 amperes at 5,100 volts, and three of 180 volts and 150 amperes.

Nottingham.—On the 18th inst., the Town Clerk of Nottingham received a cheque for £3,000 from the Drapers' Company in aid of the new Technical Schools in that town, to the charge of which Mr. William Robinson, late of the City Guilds Institute, Finsbury, has been appointed.

Hamburg.—It is said that the Senate have consented to a proposition for the electric lighting of the Hauptstrassenzug. The Rathhausmarkt and the old Jungfernstieg are already lighted by arc lamps, which will in time be also installed in the new Jungfernstieg and in Alsterdamm.

The Peral Submarine Boat.—In view of the recent successful trials with Lieutenant Peral's electric submarine vessel, the Minister of Marine has appointed a Commission to report upon the advisability of the Government ordering the construction of several submarine torpedo boats.

Robbery of Platinum.—The four prisoners who were convicted at the last London County Sessions of stealing £800 worth of platinum from the Brush Electrical Engineering Company were sentenced last week to terms ranging from five years' penal servitude to seven months' imprisonment.

Crystal Palace District.—The Bill confirming the Provisional Order for this district, which includes a part of the area controlled by the Lewisham Board of Works, and small portions of Beckenham, Camberwell, Lambeth, and Croydon, was passed last week by a Committee of the House of Commons.

British Museum.—In February, March, and April, an average of 635, 367, and 297 visitors was recorded during the evenings between 8 and 10, when the eastern and the western galleries were alternately open. This, says *The Times*, may be fairly regarded as an adequate justification of the experiment of opening the galleries at night.

Berlin.—The development of the Berliner of the Elektricitäts Werke is shown by the following table, giving the number of ampere-hours supplied for the month of August in each year since the Company was started:—

Year.	1885.	1886.	1887.	1888.	1889.
Ampere-hours	1,462 ...	5,875 ...	7,827 ...	13,290 ...	22,000

Aviles.—An installation of electric light is being arranged at the thriving town of Aviles. A rich inhabitant (the Marquis of Pinaz del Rio) is going to present the town with a complete central electric lighting station. The town is favourably situated for coal, so that altogether the cost per unit to the inhabitants will be remarkably small. The plant has been ordered in the United States.

Munich.—The gas company of this town, which has long been an obstacle to the adoption of the electric light, has reduced the price asked for their works to 5,000,000 marks (£250,000). At this price the Municipality will probably take over the concern. As gas costs 23pf. per cubic metre, that is nearly 6pf. (about ¾d.) per 16 candle-lamp hour, the inhabitants are to be congratulated on this movement.

Telephonic Communication between London and Liverpool.—The two trunk lines are now complete, each having a continuous metallic return. At present Manchester and Bradford are reached through Birmingham; but when the traffic increases, an independent pair of wires will be run to each town. One of the present trunk wires will be devoted to the use of the London and provincial Stock Exchanges.

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Telegraphic Progress in South Africa.—The Chartered South African Company's line of telegraphs has now been completed as far as Ramoutsa. The first message transmitted over the new line was one from the Chief Ikening to Sir Sydney Shippard, Administrator of British Bechuanaland. The Company is now laying the wire from Ramoutsa to Meschudi Lindewe's Town, which is to be the next station.

Wimbledon.—At a sitting of the Local Board last week the resolution in favour of electric light passed at a recent meeting of the Board was rescinded in favour of another postponing the project till September, 1891. The Local Government inquiry which was shortly to have been held to obtain the consent to borrow the £30,000 required to carry out the work, will not now take place for another year.

The Radiomicrometer.—In an interesting communication by Prof. C. V. Boys to the Royal Society on measurements of the heat of the moon and stars by means of his radiomicrometer, he gives an account of a test with a candle at 250·7 yards distance, which gave a deflection of 38mm. If ¼mm. be taken as the smallest deflection which can be observed with certainty, the instrument, as made and used by him, would show the heat of a candle at 1·71 miles distance, neglecting the absorption by the air.

Electric Treatment of Sewage at Salford.—Experiments are now being conducted at the Salford Sewage Works on an electric system of sewage purification. The water runs along a conduit in which are plates in circuit with a dynamo. The current precipitates the foreign matter from the water, whilst the effluent flows off at the end. The only drawback is that skilled attendance is necessary, and that this adds to the cost. Various Corporations and Local Boards are sending to see the process with a view to its adoption.

Aberdeen.—The Provisional Order sought by the Town Council of Aberdeen provides that the mains shall be laid within two years from the passing of the Bill confirming the Order. The undertakers are entitled by the terms of the Order to charge consumers at the following rates: For any amount up to 20 units, 12s.; for each unit above 20, 9d. per unit. It is also provided that in cases where the undertakers charge for the quantity of current used, similar rates to the above shall be charged, the potential being assumed to be constant.

City and Guilds of London Institute.—Particulars will be found in our advertisement columns of the various courses of instruction to be held during the next session, which commences on September 30th next, at the Central Institution, South Kensington. They are comprehensive in character, and include lectures adapted to the requirements of those who are preparing to become civil, mechanical, or electrical engineers. At Finsbury Technical College the term commences on the 7th of October, both in the day and evening departments.

The Electric Experiments on the Metropolitan.—The Directors of the Metropolitan Railway Company regret that the negotiations which were in progress at the date of their last report for a trial of electric traction on their railway have not resulted in a practical experiment. The use of a section of the railway beyond Neasden was offered, but the electrical engineers stipulated that the experiment should be made on a part of the Inner Circle. To this proposal, having regard to the nature of the traffic on that part of the system, the Directors were unable to agree.

Dresden.—A site for the central station has at last been selected. It will be built on a portion of the town timber-yard in the Lobtauerstrasse. Four thousand marks (£200) have been voted by the Town Council to conduct an investigation as to the best means of utilising the available water-power. A concession has been granted to a civil engineer and a firm of bankers in Dresden authorising them to establish a network of cables, for purposes of transmission of power and electric lighting, direct from some coal mines, through 168 industrial towns in Saxony, to Dresden.

Annual Dinner.—On Saturday last the *employés* of Messrs. Poole and White took their first annual excursion. The party, which numbered just over 30, dined at the Elephant and Castle Hotel, Pangbourne. Mr. J. Tryon, the chairman of the Company, presided, and referred to the success which had attended their efforts during the first six months of their existence, and said it was due in great measure to the excellent *esprit de corps* of the *employés*. Mr. Heaver, who occupied the vice-chair, proposed the toast of "The Board of Directors," to which Mr. Poole suitably replied. After a very enjoyable afternoon the party returned to town.

Lineff Tramway.—A very favourable report has been made on this system by Mr. Kapp, who calls attention to the novelty of the double set of magnetic rails. He has tested the line by taking a steam roller over it, and then drenching it with water for 26 hours, after which no fall of insulation was found, the resistance being 3,400 ohms. Tests at different speeds showed that two feet of rail under the car at either end were out of circuit. The only criticism made in the report relates to the power required to propel the magnet. This amounts to only half a horse-power at seven miles an hour, and Mr. Kapp indicates means of reducing it.

The Iron, Hardware, and Metal Trades Pension Society.—The Duke of Norfolk presided over a meeting of the supporters of this charity on the 18th inst., at his residence, Norfolk House, St. James's-square. It was established in 1843, and its annual income amounts to only £3,400. Some practical suggestions came from Mr. H. S. Kennard, who hoped that an appeal would be made to the Marquis of Bute and other influential representatives of the iron trade. Sir George Chubb proposed that residents in and around Sheffield should also be approached; and it was decided to ask the Marquis of Hartington to preside at the next dinner.

Result of Gas Monopoly at Montlucon.—The Montluçon Gas Company, according to the *Gas World*, went to law with the Municipality for allowing an electric company to come in and use the streets for carrying wires in the face of the gas company's monopoly. The gas company won its case; but its victory has turned out disastrous to it. The electric company was dying; but the public of Montluçon disliked the action of the gas company and came to the support of the electric company, which has been vigorously set on its feet. It appears that the gas company's concession expires in 1895, and will not be renewed after what has taken place. On the contrary, it will have to take up its pipes and restore the streets.

Discharge through a Lightning Arrester.—The following description of a lightning stroke has been sent to the *Victorian Telegraphic Journal* by Mr. James M'Carter, of Melbourne:—"Last Monday night (3rd March), during thunder and lightning, without rain, I 'cut out,' and shortly afterwards was shocked by seeing the office apparently ablaze, and hearing a terrific report, similar to that of a gun, but much louder. I fully expected to find the whole front of the office smashed in, and could hardly credit, on examination, that the only damage done was several of the screw points of arrester fused. The point of one screw was flattened on to the centre plate, resembling a small coin. I scraped this off, and found there was an indent on the earth plate."

Water Power at Sheffield.—The Water Committee of the Town Council, at their meeting held on the 16th, considered the question of a supply of electricity for public and private purposes within the borough of Sheffield, and passed the following resolution upon the subject:—"That in view of the probability of the Corporation obtaining power to supply electricity for public and private purposes in the borough, this committee desires to call attention to the water power connected with their several wheels in the Rivelin, and to suggest that any electrical engineer employed by the Corporation should put himself into communication with Mr. Eaton, for the purpose of ascertaining how far such power might be available for the purpose in question."

Locle.—An interesting example of an hydraulic electric light and power station was recently inaugurated at Locle, in Switzerland, which is situated in a deep valley, the far end of which is terminated by a high ridge, behind which a large reservoir has been established. Water is conducted in pipes from the reservoir to some turbines situated at the foot of the ridge. These turbines are coupled direct to 125 horse-power Thury dynamos. The current, which is at a pressure of 180 volts, is taken to the town itself, three kilometres distant, by a

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three-wire circuit. At present 185 lights are employed for public, and 1,500 lights for private purposes; 50 horse-power is also absorbed by motors, ranging in size from ½ to 6 horse-power each. The work was carried out by the municipality.

The Western Union Telegraph Company.—An explosion at this Company's offices in New York occurred at 7 o'clock on Friday morning in the battery room on the sixth floor; and the flames, which immediately broke out, soon spread to the portion of the building above, including the operating room and the offices of the Associated Press, both of which were gutted, while the lower floors were drenched with water. The loss is estimated at $250,000. The wires, with the exception of the cable lines of the Western Union Company, were concentrated in the building, and the result of the fire was that the service was greatly crippled. Business on the Exchanges in New York and elsewhere was delayed, owing to the absence of despatches. Only about 40 operators were on duty at the time, and all succeeded in effecting their escape.

Edinburgh.—Intimation was given on behalf of the following four Companies of their intention to apply to the Board of Trade in the next Session of Parliament for Provisional Orders for the supply of electricity within the area of the city:—The Scottish Electric Supply Company, the Scottish House-to-House Electricity Company, the National Electric Supply Company, and Latimer, Clark, Muirhead, and Co. Mr. Auldjo Jamieson said the Council were pledged to take the initiative in this matter themselves; and he moved that it be an instruction to the Lord Provost's Committee to take immediate steps to redeem the promise which they gave last year, and upon which these Provisional Orders were not proceeded with. It will be remembered that the Council promised that they would carry out the Orders themselves, and had no intention of applying for these for purposes of obstruction.

Electricity and Etching.—The *Papier Zeitung* of Berlin announces that an important discovery has just been made in etching, and especially in photogravure. As usual, the drawing is traced on a plate of zinc, either by an artist or by photography, with any suitable etching ground. This plate, backed with asphaltum, is laid in a bath of dilute acid. It is then put in circuit with a dynamo, the other pole being merely placed in the acid. When a current is allowed to pass, the acid attacks the metal with surprising rapidity. A few minutes suffice to bite the plate, and the depth of the etching can be easily controlled. It appears to us that the action is probably due to the depolarization of the surface of the metal, which in the ordinary method of etching becomes covered with a film of hydrogen, or, at all events, with a number of minute bubbles, which make the biting irregular unless the plate is incessantly rocked and brushed.

A Double Local Board Difficulty.—The Lancashire and Cheshire House-to-House Electricity Company are likely to have considerable difficulty with their Provisional Order for the districts of Stretford and Moss Side, near Manchester. According to their present plans they intend to build one central station for the two districts, and had applied and practically obtained an order for that purpose; but the authorities of the two districts desire to keep separate accounts, in the way of which the Board of Trade see "very great difficulty;" and there is also a difficulty caused by the fact that Stretford might be opposed to Moss Side acquiring the works at the end of 20 years. The Moss Side Local Board contend that the Company had no right to couple them with Stretford; and at their meeting on Monday a sub-committee was appointed to confer with the Stretford Board as to the advisability, under the circumstances, of opposing in Parliament the confirmation of the Provisional Order.

Water Power from Niagara.—Under the title of the Cataract Company, a syndicate in the United States proposes to utilise the water power of the Falls on a very extensive scale. There is an effective fall of about 140ft., and it is estimated that 4 per cent. of the present volume of water would yield 120,000 horse-power. The scheme is similar to one proposed a few years ago, and consists of a canal from which the water is to be supplied to turbines in vertical shafts, discharging by a tunnel passing under the town of Niagara. A tract of land above the district, purchased by the Government as a free park, is to be used for mill sites, while a considerable portion of the power is to be transmitted to Buffalo, at a distance of 18 miles. The Company have adopted the singular course of appointing an International Commission of scientific authorities, to advise them on the matter. Among the members of this Commission are Sir W. Thomson, Prof. Mascart, Col. Turrettini, Dr. Sellers, and Prof. Unwin.

Two New Insulating Materials.—The Roessler and Hasslacher Chemical Company of New York are introducing a new insulating material of remarkable qualities invented by the German chemist, Dr. Kunheim. Isolatine is said to be a bituminous viscous liquid mass, suitable for all purposes of insulation protection to electrical conductors. Its merits are that it withstands all aerial and subterraneous influences (moisture, changes of temperature, sewer and coal gases and acids) and its unchangeable toughness. It does not grow brittle or porous, but retains its elastic gum-like consistency under all conditions. Another insulating material, known as "fibrone," which is manufactured by the Fibrone Manufacturing Company, New York, has been recently submitted to the Merchants and Manufacturers' National Laboratory in that City, where it has been analysed and pronounced an excellent substitute for hard rubber. This substance is made in sheets or other forms, which can be sawed, drilled and turned with ease

Glass Insulated Wire.—The *Electrical Engineer* of New York reports that a Mr. Thomas S. Reed has devised a conductor in which the principal insulation is afforded by a layer of spun glass. The method employed consists in first winding the wire with slack-twisted yarn, either cotton or woollen, and overlaying it with longitudinal strands of spun glass. Outside of these a strand of spun glass, intermixed with silk, is wound in a close spiral, and over that a braided covering of cotton, wool, hemp, flax, silk or fine wire. The whole is coated thickly with paraffin or thick varnish, if the wire is to be exposed to dampness. If the wire is to stand hard usage, all the glass strands are loosely twisted with silk, flax, or other suitable fibre, before being applied. The wire can be glass-wound a number of times if necessary, but twice is generally sufficient. The first winding, which acts as a cushion, holds the glass strands in place, and the spiral row compresses them into an impervious surface. For extra security another spiral is wound the reverse way.

Lane Fox Patents.—With reference to our Note in last week's issue, the Managing Director of the Lane Fox Electrical Company writes as follows:—

"I trust you will allow me to correct you upon one or two points. You state that this Company was formed 'with a capital of £100 to collect royalties.' This does not fairly represent the state of the case: the Company was, in fact, formed primarily to hold the Lane Fox patents; and the nominal capital of £100 was merely registered for the purpose of apportioning the respective interests of certain individuals. You further state that we have 'now realised that there is no hope of a simple recognition of the patents.' The original scheme, with which we started, was undoubtedly to make an experiment in the direction of obtaining a recognition, without a show of force, and before negotiations were entered into for raising an adequate working capital. Although for a time our negotiations had almost come to a 'dead lock,' I may say, that owing to circumstances that have since arisen, we have not even now wholly abandoned the hope of obtaining a voluntary recognition of the patents without capital outlay. At present, it is true that we 'are not prepared to make a test case;' but negotiations are in progress, about which I can say nothing at the moment, which may have the effect of wholly altering the situation in this respect. Doubtless, as you suggest, our original policy will undergo considerable change, and, indeed, we are fully prepared so to modify it as to meet any requirements that may be brought home to us in the development of the situation."

Metallic Circuits for Telephones.—Several telephone companies in the United States, according to the *Electrical News* of Toronto, are seeking legislation to compel the railroads to discontinue the use of the earth as a return conductor, claiming that they were there first. Suits have been brought in several Courts, and the results have been various. In most of the decisions the electric railroads have been sustained. Most of the trouble can be eliminated by the use of a metallic return wire for the telephones, and this is being adopted by many of the companies as a temporary remedy. This will not only eliminate disturbances caused by electric light and railroad induction, but also the thousand and one frying, fizzling, and rattling noises, caused by battery wires, telegraph signals, earth

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currents, atmospheric disturbances, &c. Companies will see it is to their interest to provide their customers with a quiet line at all times, though the expense may at first be considerrable. One of the telephone companies in Montreal use this system with complete success, though the wires in many cases run directly upon the electric light companies' poles.

Unsuccessful Gas Opposition.—The Scottish House-to-House Electricity Company (Limited) having obtained a Provisional Order for the electric lighting of Coatbridge, the Committee of the House of Commons, on the 18th., had before them a Bill for the confirmation by Parliament of that Order. The Coatbridge Gas Company appeared to oppose the confirmation of the Order on the ground that there was no demand for electric lighting in the locality, but if an Order was to be issued it should be given only to the gas company. Evidence was given on behalf of the promoters by Bailie Crawford, of Glasgow; Mr. R. G. Mitchell, burgh engineer, Coatbridge; Mr. Angus Macleod, Glasgow; and the secretary of the applicant company. There were examined on behalf of the gas company the chairman, the manager, one of the Directors, and a London gas engineer. Mr. Pope, Q.C., and Mr. Baggallay having addressed the Committee on behalf of the promoters, and Mr. Balfour Browne, Q.C., on behalf of the gas company, the room was cleared; and the Committee, after considering the matter, intimated that they unanimously confirmed the Provisional Order. This being the first case in which a Provisional Order has been opposed by a gas company on the ground of competition is likely to form an important precedent and to regulate Parliamentary practice in the future.

The Effect of Electricity on the Coefficient of Friction.—On account of the variance of opinion on the several experimenters in this line of investigation, Mr. M. Levy, of Cornell University, applied himself to obtaining data. The apparatus used in these experiments consisted chiefly of an iron plate resting in a perfectly horizontal position on the periphery of three cast-iron wheels, the latter restricted to turning except in one direction. If not prevented the plate would therefore take up the same direction and rate of motion as the point at the periphery of the wheel in contact with the plate. This tendency of the plate to move, caused solely by the friction between the wheel and plate, was measured by suitable apparatus. Proper measurements were taken when currents varying from zero to 47 amperes passed between the surface of contact of the wheels and plate. With perfectly clean and dry surfaces of contact and about 45 amperes passing, an increase in the coefficient of friction amounting to about 119 per cent. was observed. When the surfaces of contact were bathed in oil 40 amperes increased the coefficient of friction by almost 108 per cent. With a thin coating of oil 47 amperes increased the coefficient 133 per cent. Up to 41 amperes water seemed to prevent the above observed effect of the current. A current of 40 amperes through the surface of contact of wheels and plate corresponds to a current-density of no less than 5,000 amperes per square inch.

The Thunderstorm.—The storm which was raging as we went to press last week was more remarkable for the rainfall than for damage done by lightning. At Stanmore 2·91 inches of rain were recorded in 12 hours. The flagstaff over the Free Library at Southampton was struck by lightning and much splintered. The shock of the electric discharge shook the building, and for a short time there was something like a panic in the reading-room. A tradesman standing at his door at the time noticed the lightning descend, as though in a ball of fire, from the flagstaff towards the centre window of the Library, and then disperse in the air with a loud report. During the thunderstorm a curious accident occurred at Freemantle, in a house in Nelson-road. According to a local paper the lightning got under the roof, stripped a considerable portion of it off and knocked off several chimney-pots. Passing down one of the chimneys leading to the living-room, the electric fluid lifted the kitchen range right out into the centre of the room. At the Common Room, Lincoln's Inn, a boy's hand resting on the speaking tube was knocked away and hurt, but was not marked. There was no reverberation, but a sharp crack, simultaneous with the flash, like the explosion of a gigantic copper gun-cap; and the only damage done was the splitting of a portion of a gaspipe in the basement, the soft metal melting and falling in splashes on the floor. The gas was ignited at the fissure. Had not the steward, with commendable promptitude, turned off the gas at the meter a fire would have occurred. At Longham, in the New Forest, three farm labourers took shelter from the storm under a tree, and one of them was killed by the lightning.

The Telephone in Kent.—The Kent County Council have had notification given to them by the South of England Telephone Company (Limited) of an intention to erect trunk communication between Sittingbourne and Maidstone to connect Maidstone with the East Kent system, and between Ashford, Bennington Lees, Challock Hill, Moldash and Chilham and also between Teynham and Sittingbourne. The committee, who have considered the application as a basis for future guidance, have drawn up the following rules:—(1.) That a rent of £1 per mile of the system be paid to the county. (2.) That the poles and wires be removed upon three months' notice being given by the Council. (3.) That all present or future county buildings and offices of county officers along or near the line of telephone will whenever practicable be connected with the Company's system, and suitable instruments kept in efficient working order, free of cost to the county, and that no rent be charged for the user by or on behalf of the county for the same. (4.) That any damage done in the construction or maintenance of the work be made good by the applicants, who shall also be made to undertake the entire liability of any damage or injury to property or to any persons that may result from defect or breakage or any other cause. The approval of the County Surveyor to be obtained as to the position of the poles before the same are erected, and no struts or straining wires to be permitted beyond the face of the poles. —These conditions having been adopted at a meeting of the Council they will become part of the county's bye-laws. It has been stated that the Telephone Company has no objection to these conditions, or otherwise some of the members of the County Council would not have agreed to charging the rental, they being of opinion that everything should be done to facilitate telephonic communication.

Municipal Control of Electric Lighting in America.—There seems to be a difference of opinion as to the relative advantages of electric lighting by municipal authorities or by private companies in the United States. Mr. M. J. Fancises, writing to the *Electrical Engineer* of New York, June 25, combats the views set forth in a previous issue of that journal by Mr. Rosewater, of Johns Hopkins University. He says that the latter claims that hired politicians, whose tenure of office is but for one year, without experience or knowledge of the business and with no financial interest in it, with the exception of their salaries, will give the tax-payer better service than the private corporation. The manager of an electric light company, however, is personally interested, and knows that its success depends upon his furnishing the best service at fair rates. Now, in order to accomplish this, it is evident that he will bring to his aid all that years of experience have taught him is best in electrical apparatus, together with the latest inventions and improvements. Several cities owning plants, having found by actual experience that the service and expenses relating to the same were unsatisfactory, are now considering the advisability of abandoning the control of the plant, and are negotiating for contracts with electric light companies to light their streets. Philadelphia, owning an immense gas plant, which Mr. Rosewater says the "Select Council were wonderfully pleased with, because they were making a profit," has contracted with electric light companies to light the streets for $177 per year each lamp, or more than three times the amount he claims as the average cost for those cities producing their own lights. The taxpayers of Philadelphia have had an experience with both plants, and evidently think any price a private corporation will offer is cheaper and better than municipal control. Hypothesis and theory may do on paper, but actual results obtained by practical application and experience are the only reliable data upon which to base any statement relating to the cost of street lighting. In every case these have shown, where all the facts are given, that it has been for the best interest of the citizens and taxpayers to contract with an electric light company for lighting the streets of any city.

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MAGNETISM IN IRON AND OTHER METALS.*—XXIV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 251.*)

§ 91. **Magnetisation in Strong Fields.**—We pass now to speak of the opposite extreme of the magnetising process. In studying the relation of magnetism to magnetising force by any of the methods which have been described in earlier chapters, it is scarcely practicable to raise the force H beyond a few hundreds of C.-G.-S. units at the most. Formidable difficulties present themselves, the chief of which comes from the heating effect of the magnetising coil. Special methods have therefore to be resorted to when we wish to examine the behaviour of iron or other magnetic metal in very strong fields.

It is true that the most important parts of the magnetising process lie within the range of those forces which may easily be produced by means of a magnetising coil. Within that range the permeability or the susceptibility passes through its great changes, increasing quickly from a small finite initial value to a maximum ten or fifteen times as great, and decreasing almost as quickly to a value smaller than the first. Within that range, too, the residual magnetism apparently reaches the full value it is capable of reaching. It is within that range that the most prominent features in the influence of vibration, of temperature, and of stress, manifest themselves. And it is probably true that whatever knowledge of magnetic quality is wanted for application to the practical ends of electrical engineering can be obtained by experiments within that range.

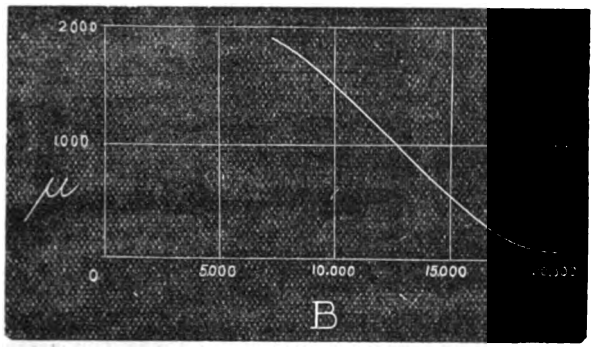

FIG. 63.—Permeability of Wrought Iron when strongly magnetised.

But still the action of stronger fields is of very great interest, especially in relation to the molecular theory of magnetism propounded by Weber. According to Weber's theory the molecules of iron or any other magnetisable metal are always magnets. These point anyhow in the unmagnetised piece, so that the sum of their moments, resolved in any direction, amounts to zero, and the piece, therefore, has no magnetism as a whole. But when a magnetising force acts the molecular magnets tend to turn, so that their axes point more nearly in the direction in which the force acts; and thus the piece, as a whole, becomes a magnet. The intensity of magnetisation I is the sum (per unit of volume) of the moments of the molecular magnets resolved in the direction of the magnetising force. We shall discuss this theory more fully in a later chapter. Meanwhile, one obvious deduction from it may be pointed out. When all the molecular magnets are turned round to face exactly in the direction in which the force acts, no further magnetisation in that direction will be possible, however much the force may be increased. In other words, the theory points to this—that the intensity of magnetisation I has a saturation value which cannot be exceeded, though it points to no limit to the value which B, the magnetic induction, may reach.

In experiments made with moderately strong magnetising forces both B and I are increasing slowly at the last; and it is impossible to infer, from the results of such experiments, whether B or I or either of them is approaching a finite limit. The curves of permeability or of susceptibility in relation to B or to I (such as have been given in Figs. 40, 41, and 42) do not help us to a conclusion; we cannot produce a curve of this kind beyond the region of experiment until it cuts the axis of B or of I, because (as Figs. 41 and 42 show) the curve bends out when the magnetising force is sufficiently increased. This characteristic of the curve of κ and I or of μ and B was first pointed out by Fromme,* and has been commented on by a number of other experimenters. In some of the writer's experiments it appeared when B exceeded about 15,000.† Figures given by Bosanquet‡ for experiments with iron and steel rings, in one of which the induction was pushed as high as 19,300, show when plotted a similar inflexion in the curve of μ and B occurring when B is about 15,000. The same feature is well shown in Fig. 63, which is copied from a Paper by Bidwell,§ describing experiments with soft wrought iron, in which the induction was raised to 19,820, with the result of reducing μ to 33·9. To produce this the force H was 585, and the resulting magnetisation I was 1,530. These numbers give some idea of the extent to which experience has shown it is practicable to go in experiments of the ordinary class, using the magnetising force of a current in a coil.‖ To answer the question whether there is any finite limit to I or to B, we have to go far beyond this range.

§ 92. **The Isthmus Method.**—This name has been given to a method introduced in 1887 by the writer and Mr. W. Low,¶ which has allowed the magnetisation of iron to be raised to greatly higher values, with the result of showing that, while B has apparently no limit, there is a finite limit to I, as Weber's molecular theory predicts.

In the air-space between the pole-pieces of a strong electromagnet, we have a magnetic field of much greater intensity than any that can easily be produced by the direct action of the electric current. If a small test piece of the metal which is to be magnetised be placed across this space, so that it forms an isthmus between the two pole-pieces, it will become strongly magnetised. In becoming magnetised, however, it disturbs this field, and the force acting on it may be very different from the force which existed in the empty space. If it is a short cylinder extending lengthways from pole-piece to pole-piece, its magnetism will be very unequal. At the ends the induction will have the same value as it has in the pole-pieces themselves; at the middle it will be stronger, owing to the convergence of lines of induction from neighbouring parts of the pole-pieces, which find their way into the test-piece through its sides. Evidently we may increase the induction in the middle by furnishing the specimen with spreading ends, which will present an easier path along which the lines of induction may converge. Moreover, when the test-piece takes the form of a bobbin, with a short, narrow, central neck from each end of which a cone extends, spreading over the face of the pole-piece, it becomes possible (by giving a proper form to the cone) to secure that the central neck will be uniformly magnetised, and that the magnetic force which acts on it will have the same value as the magnetic force in the immediately surrounding air-space. The magnetic force and the magnetic induction within the neck then admit of being measured, and the permeability, susceptibility, and intensity of magnetisation under exceedingly strong forces are readily deduced.

§ 93. **Early Experiments, using the Isthmus Method.**—Figs. 64 and 65 show two forms of bobbin which were used in the first application of the isthmus method. The dimensions are marked in millimetres. The central neck was wound with an induction coil consisting of a single layer of fine wire, and its magnetism was measured by the ballistic method. With bobbins of the shape shown in Fig. 64, the induction was measured by suddenly slipping the bobbin out from its place between the pole pieces while the electro-magnet was excited. An

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* Fromme, *Gött. Nahr.*, 1875, p. 500. Wied. *Ann.* XIII., p. 695, 1881; *see* also J. Haubner, *Wien. Anz.*, October 21, 1880; Wied. *Beiblätter* V., 1881, p. 205.

† *Phil. Trans.*, 1885, Part. II., p. 567.

‡ Bosanquet, *Phil. Mag.*, February and May, 1885.

§ Bidwell, *Proc.* Roy. Soc., Vol. XL., 1886, p. 486.

‖ In recent experiments by du Bois, described in § 107 below, a coil was used to produce magnetic forces which ranged up to 1,300 C.-G.-S.

¶ *Proc.* Roy. Soc., March 24, 1887.

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objection to this is that it takes no direct account of the residual induction; it shows only the magnetism that is lost when the bobbin is withdrawn from the field. The residue is small, and it may be separately measured and allowed for; but a better arrangement is shown in Fig. 65, where the bobbin may be turned suddenly round so that its magnetism is reversed; half the ballistic effect of this reversal of course measures the magnetic induction. To measure the field in the air-space immediately surrounding the neck, a second induction coil was wound over the first, but at a little distance from it, so that a narrow ring of non-magnetic space—about 1·3mm. wide—was included between the two. The magnetic force in this space was calculated from the observed difference in the ballistic

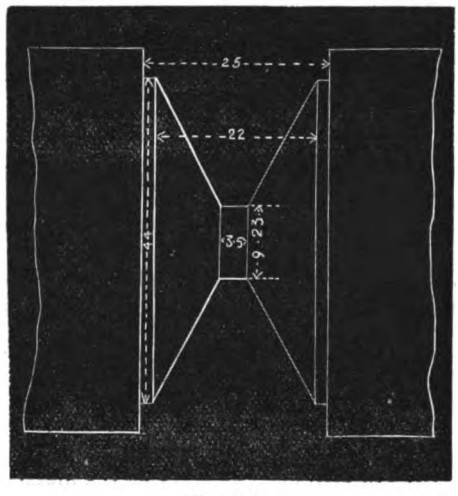

Fig. 64.

effects of the inner and outer coil. The knowledge of it allowed a proper correction to be made, by which the whole induction within the inner coil was reduced to allow for those lines of induction which lay within it but not within the iron.

With the bobbins shown in Figs. 64 and 65 the outside field —that is to say, the magnetic force in this narrow ring of space surrounding the neck—was probably a very little stronger than the mean force within the metal of the neck itself. Still, the

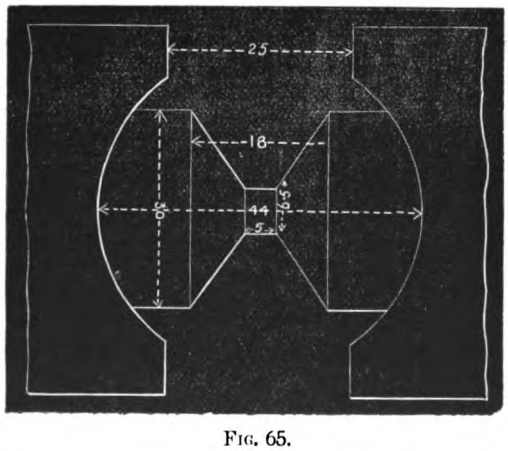

Fig. 65.

outside field was so nearly equal to **H**, that the quantity $\frac{\mathbf{B} - \text{outside field}}{4\pi}$ approximated closely to the value of **I**, and the quantity $\frac{\mathbf{B}}{\text{outside field}}$ approximated closely to the value of the permeability, μ.

The results in Table VIII. were obtained with a bobbin of soft Swedish wrought iron in the annealed state.

These figures show that in the very strong fields with which this experiment deals, the quantity in the third column, which is approximately equal to the intensity of magnetisation **I**, becomes practically constant. Such variations as occur in the numbers are irregular and come from errors of observation. The iron is here in a condition of true saturation; **I** has reached a value which refuses to undergo any sensible increase, though the strength of the field be doubled; but the field itself may be increased without limit, and consequently there is no sign of any limit to the value of **B**.

Table VIII.—*Swedish Wrought Iron in Strong Fields.*

Outside field (=**H** nearly).	**B**	$\frac{\mathbf{B} - \text{outside field}}{4\pi}$ (=**I** nearly).	$\frac{\mathbf{B}}{\text{outside field}}$ (=μ nearly).
6,690	27,960	1700	4·18
8,900	29,730	1660	3·34
9,510	30,820	1700	3·24
10,000	31,210	1690	3·12
10,360	31,630	1700	3·05
10,810	31,720	1670	2·94
10,880	32,060	1690	2·95
11,200	32,360	1690	2·90

Table IX. gives the results of a similar experiment made with a bobbin of annealed Lowmoor wrought iron, and with a wider range of magnetic forces. The apparent decrease of **I** in the strongest field, which is shown by the last numbers in the third column, is due to the fact that the outside field was rather greater than the true magnetic force within the metal. When the bobbin is so shaped that this source of error is avoided, the apparent decrease disappears, and **I** is then found to be as nearly constant as casual errors of observation allow it to be.

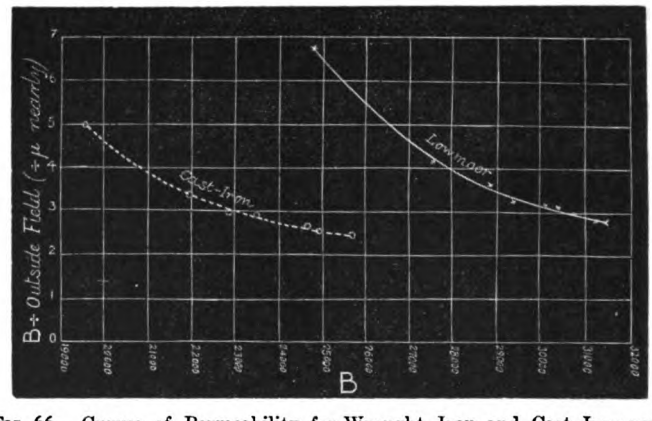

Fig. 66.—Curves of Permeability for Wrought Iron and Cast Iron very strongly magnetised.

A noticeable feature in these results is the reduction of the permeability that is brought about by continuing to increase the magnetising force after a state of saturation has been reached. With wrought iron such as was used here the initial value of μ for exceedingly small forces is nearly 200; and the maximum of μ, reached generally with a magnetising force of two or three units, may be as much as 3,000. Here, with a magnetising force of 10,000 units or so, μ has fallen to less than 3.

Table IX.—*Lowmoor Wrought Iron in Strong Fields.*

Outside field (=**H** nearly).	**B**	$\frac{\mathbf{B} - \text{outside field}}{4\pi}$ (=**I** nearly).	$\frac{\mathbf{B}}{\text{outside field}}$ (=μ nearly).
3,630	24,700	1680	6·80
6,680	27,610	1670	4·13
7,800	28,870	1680	3·70
8,810	29,350	1630	3·33
9,500	30,200	1650	3·18
9,780	30,680	1660	3·14
10,360	30,830	1630	2·98
10,840	31,370	1630	2·89
11,180	31,560	1620	2·82

Table X. gives the results of a similar experiment with cast iron. In it, as in the two last cases, saturation has been reached even with the lowest value of **H** within the range of

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the observations. The saturation value of I in this cast iron is about 1,240—a value distinctly less than that found in wrought iron. Fig. 66 exhibits the results in Tables IX. and X. in the form of curves of permeability. These are in effect an extension into regions of strong force of curves of the type shown before in Figs. 41 and 42, and in Fig. 63.

TABLE X.—*Cast Iron in Strong Fields.*

Outside field (=H nearly).	B	$\frac{B}{4\pi}$ = outside field (=I nearly).	$\frac{B}{\text{outside field}}$ (=μ nearly).
3,900	19,660	1250	5·04
6,400	21,930	1240	3·42
7,710	22,830	1200	2·96
8,080	23,520	1230	2·91
9,210	24,580	1220	2·67
9,700	24,900	1210	2·57
10,610	25,600	1190	2·46

(To be continued.)

VERIFICATION OF OHM'S LAW.

In one of the Circulars issued to the Electrolysis Committee of the British Association, viz., that dated June 24, 1886, Prof. Fitzgerald suggested an objection to the complete validity of the theory of the experimental mothod of verifying Ohm's law with twelve-figure accuracy, devised by Clerk Maxwell, and carried out by Mr. Chrystal; doing so in the following words:—

"There is an objection to this method that I have not seen noticed. Maxwell assumes that you can expand in powers of $\frac{C^2}{S^2}$. Now, if the law were the positive value of $\left(\frac{C}{S}\right)^n$ where n differs very slightly from unity, the method would fail, for the current would vanish both in the numerator and in the denominator of Maxwell's expansion."

Maxwell's Theory is given in the Glasgow volume of the British Association for 1876.

Recently Dr. Fison seems to have promulgated the same objection, and consequently Prof. Fitzgerald wrote to Prof. Chrystal about it. In reply he received a very interesting letter, which he has passed on to me, and from which I extract the portion referring to this subject, sending it herewith for publication. OLIVER J. LODGE.

Letter from Prof. Chrystal to Prof. Fitzgerald.

. . . The problem which I set myself in the Ohm's law experiment was to show that when a Wheatstone's bridge is balanced for any electromotive force in the battery circuit, it is balanced for every, or, to put it safely, for widely varying electromotive force.

The theoretical part of the Paper, for which Maxwell was responsible, I do not remember ever having examined from a sceptical or logical point of view.

It now appears to me that we ought to reason as follows:—

In order to find the necessary condition upon the resistance-function E C, let us make matters as simple as possible by considering a bridge in which two arms, R, R, are of equal resistance, of the same metal, and *alike in every respect*. Let the two other resistances S and T be made of two different metals, say of Cu and Fe. Let the length and section of S be l and ω; and the length and section of T be l' and ω'. The specific resistance must in each case be a function of the current intensity (current per unit of section). Temperature is supposed kept constant, of course. Let the whole current flowing through S and T when there is balance be i, the specific resistances of S and T will be $\phi(i/\omega)$ and $\psi(i/\omega')$ respectively.

The condition for balance will therefore be

$$(l/\omega)\,\phi(i/\omega) = (l'/\omega')\,\psi(i/\omega') \quad . \quad . \quad . \quad . \quad (1);$$

and this equation must, by the result of the experiment, *hold for all values of i*.

Let us suppose that we alter the length of the iron wire S to l'', then there will be a corresponding section ω'', for which there will again be a balance; so that we must have

$$(l''/\omega'')\,\phi(i/\omega'') = (l'/\omega')\,\psi(i/\omega') \quad . \quad . \quad . \quad . \quad (2);$$

and this again must hold for all values of i.

Combining (1) and (2) we get

$$(l/\omega)\,\phi(i/\omega) = (l''/\omega'')\,\phi(i/\omega'') \quad . \quad . \quad . \quad . \quad 3)$$

From this equation we can readily determine the form of the function ϕ.

If we put $\mu = \omega''/\omega$, $\lambda = l''\omega''/l\omega$ $x = i/\omega''$, we get

$$\phi(\mu x) = \lambda\,\phi(x);$$

whence, putting $x = \mu x$, we get

$$\phi(\mu^2 x) = \lambda\,\phi(\mu x) = \lambda^2\phi(x);$$
$$\phi(\mu^3 x) = \lambda^3\phi(x);$$

and, in general,

$$\phi(\mu^n x) = \lambda^n\phi(x).$$

Hence, putting $x = 1$, we get

$$\phi(\mu^n) = \lambda^n\phi(1).$$

Now μ is unrestricted, therefore we may put

$$z = \mu^n, \quad n = \log z/\log\mu.$$

Whence, finally,

$$\phi(z) = \lambda^{\log z/\log\mu}\phi(1).$$
$$= z^{\log\lambda/\log\mu}\phi(1).$$

The general form for $\phi(z)$ is, therefore,

$$\phi(z) = A\,z^B,$$

where A and B are constants, the physical meanings of which are obvious from what precedes.

We see from equation (1) that the like holds for the specific resistance of every metal which has the property indicated by the experiment.

Moreover, as you have pointed out, such a law of specific resistance is sufficient to secure the result of the experiment.

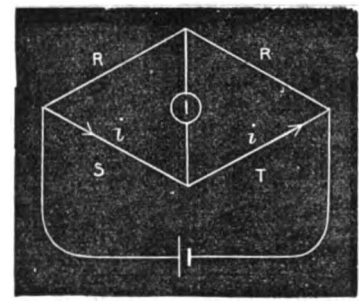

FIG. 1.

We conclude, therefore, that what the experiment really proves is that the specific resistance of metals varies as a power of the current intensity, *which power is the same for all metals*. This is a good deal, but not quite so much as is concluded in the Paper in which the experiment was originally described. The deviation spoken of in the Paper must, therefore, be regarded as deviations not from *absolutely constant resistance*, but from the *resistance calculated according to the above simple law*.

To establish that the constant B is zero will not be quite so simple a matter. Many ways might be suggested, and will, doubtless, occur to you. The most direct and satisfactory would be to get the resistance for different current-intensities, in Joule's way, by measuring the heat evolved.

Should the above sophistry be right, it is curious that you and Dr. Fison should each have suggested not *a way*, but *the only possible way* in which the resistance may vary with the current, and Wheatstone's bridge still remain the ideal instrument that electricians have always considered it to be. G. CHRYSTAL.

OBSERVATIONS ON CURRENTS ORIGINATING IN ORDINARY AERIAL TELEGRAPH CONDUCTORS.*

BY A. R. BENNETT, M.I.E.E.

All users of telephones connected by single wires are familiar with the variety of noises which are generally present, even when the line is only a few hundred yards long. It is exceptional to find a wire which can be said to be even approximately silent at all times. The origins of some of the foreign currents which the presence of these noises indicates have been explained by Preece, Lockwood, and others. Recently in testing some overhead copper and iron wires run on the same poles for capacity by charge and

* Paper read at the special meeting of the Institution of Electrical Engineers, held at the Edinburgh International Exhibition, July 15, 1890.

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discharge, using a sensitive reflecting galvanometer, the author noticed the presence of currents which could not be accounted for by any of the known explanations, and the causes of which he determined to investigate.

It was noticed that soon after the commencement of rain, a steady current appeared on all the wires under test. The deflections increased as the rain continued, until, after the thorough soaking consequent on several days' wet, they were in some case no longer within range of the scale. A constant discrepancy in the behaviour of copper and iron wires was apparent. The deflections from the copper were always positive, while those from the iron were always negative, and invariably much feebler, seldom exceeding one-third the strength of the positive ones.

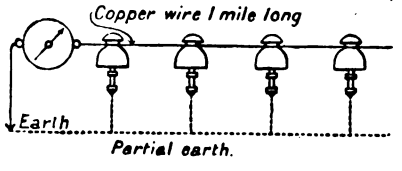

FIG. 1.

To ascertain the cause, two wires, one No. 12½ copper and the other No. 11 galvanised iron, run side by side on the same arms for the distance of a mile (Fig. 4), were taken. In fine weather the insulation resistance of each was infinite.

When disconnected at the further ends and earthed at the home end through the reflecting galvanometer (Fig. 1.), they always in wet weather exhibited the phenomena described.

The following are extracts from the records of tests, extending over several months, during medium and heavy rain :—

Copper (always positive).		Iron (always negative).	
Degrees.	Value of deflections in milliamperes.	Degrees.	Value of deflections in milliamperes.
4·5	·0030375	1·5	·0010125
13·0	·008775	3·75	·00253125
20·5	·0138375	4·0	·002700
17·0	·011475	3·0	·002025
15·0	·010125	4·5	·0030375
3·0	·000025	17·5	·0003375
46·0	·031050	17·5	·0118125
22·0	·014850	7·0	·004725
14·5	·0097875	3·5	·0023625

It will be observed that the copper deflections were always from three to six times stronger than the iron ones. When the copper

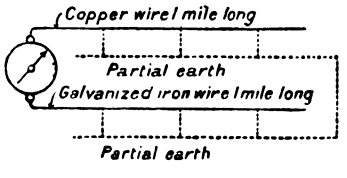

FIG. 2.

and iron wires were left insulated at their distant ends, and looped through the galvanometer (Fig. 2), earth being excluded, the positive and negative deflections were always equal. Thus, taking the last three of the foregoing tests, when looped 46+17·5− became 35+35−; 22+7− became 12·5+12·5−; 14·5+3·5− became 9·7+9·7−.

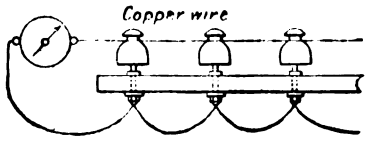

FIG. 3.

Half-a-dozen insulators, with galvanised iron bolts, were mounted on an arm in the testing-room, and thoroughly wetted (Fig. 3). With a copper wire run on them, and the bolts connected as shown, a positive current appeared as soon as a film of water was established between the wire and the bolt. With an iron wire instead of the copper no current appeared. The positive current, therefore, seemed to be due to voltaic action between the copper wire on the insulators and the galvanised iron bolts supporting them when connected with the moist surface. The course of the current can be traced in Fig. 1. The wire and insulator bolts form a series of voltaic cells joined in parallel.

The absence of a current from the iron when mounted on the experimental arm confirmed this conclusion, since no current was to be expected under the conditions. But whence then the negative current from the iron wire run on the actual poles? In that case it had a copper wire strung alongside it (Fig. 4). The wetting of both insulators established the connection necessary for electrolytic conduction between them, so that the metals constituted a voltaic couple, the negative current from which appeared on the iron.

The positive current on the copper was consequently due to the copper wire acting with the iron bolts of its own insulators, the iron bolts of the neighbouring insulators and the iron wire which they supported.

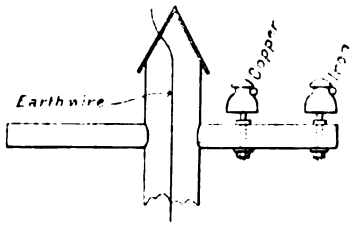

FIG. 4.

The negative current on the iron was due to the iron wire, its bolts and the bolts of the neighbouring insulators acting with the copper wire. But the bolts of the insulators (Fig. 4) were partially earthed by the damp wood of the poles and the earth wires which ran down them. If the earth had been perfect no current could have got to the galvanometer, but since it was only partial some found its way by that route; and so the difference in strength between the positive and negative currents is accounted for.

The positive, depending chiefly on the action between the copper wire and its own bolts, between which no earth intervenes, is necessarily stronger than the negative, which depends wholly on the action between the iron wire and bolts and the copper wire between which a partial earth is interposed (Fig. 5). So when the earth is cut off from the galvanometer (Fig. 2) the effect of the earth between the two plates is neutralised, and the positive and negative deflections become equal.

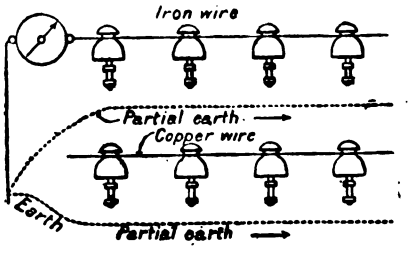

FIG. 5.

A somewhat unexpected effect of the recent introduction of copper wires for telegraph and telephone purposes is consequently the establishment over the country of a vast number of voltaic couples, which only become operative in damp or wet weather.

The zinc of the bolts of insulators carrying copper and bronze wires may reasonably be expected to disappear sooner than in days gone by when only iron wire was used; and when copper and iron wires are run on the same poles the galvanising of the iron must suffer sooner than of yore.

The Americans, with their wooden pins, will escape the currents due to the difference of metal between the wire and its supports: but when they mix wires of different metals on the same poles the resulting action will be stronger than with us, since they do not earth-wire their posts. Telephonically, the existence of these currents is of little moment. With metallic loops, when both wires are of the same metal, they will not matter at all, since the currents from two similar wires will be in the same direction and of the same strength, and, meeting in the telephone or translator, will neutralise one another.

On single wires, so long as the currents remain steady, their presence does not matter much. As they increase gradually as the insulators become wet, and die away slowly as they dry, they do

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not give rise to any disturbance in the telephone. If any confirmation of the voltaic origin of these currents were needed, it would be afforded in the fact that it is possible, by charging the line from a battery, to polarize the line couple even to the extent of obtaining temporary currents of the opposite sign. Thus, the copper was repeatedly charged from a 90-volt battery; when from the positive pole the line current was increased, when from the negative the line current was decreased and sometimes reversed.

The following are particulars of several tests of the copper wire, the deflections being in degrees:—

Charging Wire from 90 volts, – to line, so as to neutralise and overcome Line Current.

Line current.	Duration of charge.	Result.
·5+	10 seconds	Reversed to ·2–
6° +	20 „	Reduced to 5·0+
8·4+	4 minutes	„ „ 3·5+
12·5+	10 seconds	Reversed to ·2–
	Spot went back instantly to ·5+, and then recovered slowly to 12·5+.	
12·5+	20 seconds	Reversed to ·4–
	Went backly quickly at first, and then slowly recovered to 12·5+ in 45 seconds.	
12·5+	1 minute	Reversed to ·8–
	Went back instantly to 3·5+, recovering slowly to 12·5+ in 70 seconds.	
12·5+	2 minutes	Same as 1 minute
12·5+	3 „	„ „

The same effects were produced with the experimental arm. With only one insulator, reversed, the cup being full of water and the surface well wetted, a deflection was got of 4deg., equal to ·0027 milliamperes. When the current from this insulator was reduced to ·2+ through the surface drying, a reversal could always be obtained to ·4–, and sometimes to 6·– by charging it from 90 volts.

During the capacity tests already mentioned, it was observed that for some time after the commencement of rain, the apparent capacity of the wire invariably rose instead of falling with the decrease of insulation. This effect has, of course, been noticed before; but as the author was not aware that it had been satisfactorily accounted for, it was resolved to investigate, and the result of the investigation seems to point to several contributory causes. Firstly, no doubt, the line current due to the voltaic action already described will increase or diminish the discharge according to the direction of the charging current. Secondly, the polarisation of the bolts due to the charging current will have the same tendency. But the capacity of the line will appear too high when the moisture on the insulators is too slight to permit of voltaic action. To seek the cause of this, 12 feet of copper wire was run on six dry insulators, fixed in oaken arms in the test-room. With 90 volts the wire gave a discharge of ·4deg. The tops of the insulators around the binding wire were wiped with a wet sponge. The discharge then rose to 1deg., more than double. Wetting more of the surface of the insulators resulted in a still further increase. Several discharges could be got without renewing the battery charge. It would, therefore, appear that wetting the insulators is equivalent to an increase of conductor surface. The moisture has to be charged as well as the wire, and the consequent discharge is greater than with a dry wire. The effect is only observable in moderate rain or for some little time after the commencement of heavy rain; when the insulators become thoroughly wet, the insulation and the capacity fall together, and then the voltaic action and polarisation come into play, together with another phenomenon which has not yet been referred to.

Incidentally, in the course of these tests, it was found that when a wire is in contact with moist wood, and is charged from a powerful battery (90 volts were used) the discharge is several times stronger than when the same wire is supported on dry or partially moist insulators. Thus a length of wire on insulators gave a discharge of ·9deg.; when stapled along an oaken arm not sensibly damp, the discharges, after 20sec. charge, amounted to 4·5deg., and after 80sec., to 5deg. Then a residual charge appeared to remain in the wood, as the wire continued to yield a current of ·5deg. for some minutes, then gradually dying away to nothing. Many tests, varied in details, gave the same results; 30ft. of wire in air gave a discharge of ·4deg. When the same wire was stapled on a deal board (Fig. 6) not sensibly damp, with staples of the same metal as the wire, the discharge became 3·5deg., falling immediately to 1deg., and then slowly to zero. The wire and the wood were then sponged, and the discharge rose to 7deg., falling immediately to 2deg., and returning slowly to zero. The wire yielded a series of smaller discharges for several minutes without any fresh contact with the battery. A deal box wetted, having some bronze wire in contact with it, was well insulated by being suspended by G. P. Charged for 20sec. from 90 volts, it gave a discharge of 1·6deg., sinking immediately to ·8deg., and then gradually to zero. The same box standing on the floor, gave a discharge, under the same conditions, of 12deg., sinking to three degrees, and then slowly to zero. The same box touched by the end of an earth wire—also of bronze—well away from the bronze wire, gave a discharge of 45 degrees, sinking immediately to 26 degrees, and thereafter slowly to zero. In the two first cases only one metallic conductor, that is to say, the bronze, through which the charge was communicated, was present, and the source of the return current is not very apparent.

The last case closely resembles that of a wet telegraph pole, the earth-wire of which does not touch the bolts. Then an expanse of wet wood intervenes between the bolts and the earth, and a powerful charging current in the line must, with leaky insulators, result in back currents. As it is evident that moisture in wood has the effect of increasing the capacity, it may not be unreasonable to deduce that moisture in the air surrounding the wire may have the same effect.*

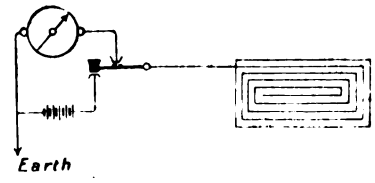

Fig. 6.

The foregoing particulars apply whether the line is of copper or of iron. The following observation applies to iron alone. It has been mentioned that no current between a galvanised iron wire on a wet insulator and the bolt could be detected. But if such a wire is charged by 90 volts, the discharge is followed by a counter-current from the insulator. The effect can be produced with a few inches of galvanised iron wire and a wet insulator, as in A, Fig. 7. Charging such an arrangement by 90 volts yielded a discharge of ·4 degrees and a counter-current of ·3 degrees, which did not wholly disappear for some three minutes. Obviously, the polarisation of the bolt following on electrolysis of the moisture made the insulator a secondary battery. The effect of damp wood may be markedly shown by shifting the return wire to the bolt of an adjoining insulator, as in B, Fig. 7. The discharge then became 1·5 degrees and the counter-current 1 degree, an augmentation of nearly four times. Connecting the earth-wire direct to the bolts will obviate the effect of moist wood, but it increases the strength of the voltaic action and the polarisation of bolts by the charging current.

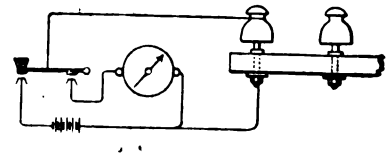

Fig. 7A.

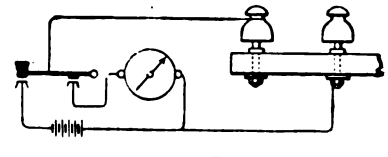

Fig. 7B.

Although the Americans escape the voltaic action consequent on the use of metallic bolts, the damp wood of their poles cannot be without its effect in wet weather with the insulators they use.

The current set up between copper wire and iron bolts in wet weather might be used to signal with. The experiment has not been tried; but it seems plain that a galvanometer at A, Fig. 8, through which the line current circulates in its full strength when the wire is insulated at B, would be affected by the working of a

* Note.—Since reading the Paper it has occurred to the author that the probability of this conclusion is strengthened by considering that dry and moist air have very different capacities for heat. Tyndall found that the absorption of heat by dry air being 1, that of the air of his laboratory, not specially damp, was 72, while that of air designedly moistened was no less than 90. Thermal and electrical vibrations differ only in frequency, so that some common absorptive action in respect to air may be looked for. The heat absorbed by the moisture in the air is, after the withdrawal of the source of heat, radiated or discharged, not instantly but gradually; just as the electrical charge, after the cutting off of the battery, is parted with slowly and by degrees, as indicated by the residual charge. It may be expected, therefore, that the apparent capacity of a conductor will be least when contained in artificially dried air.

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key between the line and earth at B; for the key, when closed, would shunt a large proportion of the current away from the galvanometer.

It will be observed that these experiments were made with the distant ends insulated—a condition which does not obtain in ordinary telegraphy. The practical effect of the disturbances noted

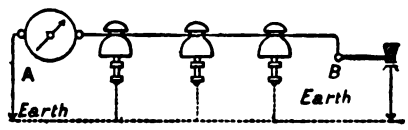

Fig. 8.

may be insignificant, especially with the double-current working, but still it is well to know that they exist.

[The discussion which followed the reading of this Paper will appear next week.]

SOME EXPERIMENTS UPON ALTERNATING-CURRENT APPARATUS.*

BY HARRIS J. RYAN.

It is well known that when the core of a transformer is heated under certain favourable conditions, the secondary will deliver electrical energy in amount considerably greater than when the core is not heated; and that this is done, too, without an increase of the energy supplied to the primary. It is stated, in fact, that with a heated core the energy taken up by the primary is less, while that given out by the secondary is greater.

Mr. L. B. Marks, of Cornell University, made an apparatus in which he found this phenomenon very marked; and his experiments are of interest since they indicate the source of energy in the phenomenon observed, and also because they exhibit, in an exaggerated form, certain other phenomena which must be done away with in a transformer that is to be used for incandescent lighting.

The apparatus included a transformer, whose core consisted of well-rusted wire rings, 1·1cm. thick, and of a mean diameter of 17cm. The primary and secondary circuits were wound on opposite parts of the core, and consisted of 500 and 155 turns respective y. The size of bare copper wire in each was No. 18 B. and S. G. The wire was insulated with asbestos paper, and because of its thickness the primary and secondary turns, with their insulation, occupied a space of abnormal proportions. The resistances of the primary and secondary circuits were 1·65 and 0·71 ohms respectively. The maximum intensity of magnetisation used in the core did not exceed 3,000 lines per square cm. The iron core could be heated by means of a gas flame.

The shape of the curves connecting the electromotive forces, and the currents with time, were obtained by a method due to Prof. Ryan, and already described.† The curves obtained are of the same character as those given in Prof. Ryan's Paper already referred to, and are also very similar to those given in Humphrey and Powell's Paper in a recent issue.

Table I.

—	Temp.	Primary E.M.F.	Sec. E.M.F.	Ratio of E.M.F's	Primary watts.	Sec. amps.	Sec. watts.
Secondary open, no heat applied to core	97·5°C.	75·6	16·4	4·6	87·0	0·0	0·0
Secondary open, heat applied to core	300°C.	93·4	24·5	4·0	88·0	0·0	0·0
Secondary closed, no heat applied to core	100°C.	89·3	11·9	8·1	139·0	2·0	24·0
Secondary closed, heat applied to core	270°C.	95·7	13·4	7·1	129·0	2·4	3·67

Table I. gives the particulars of the measurements made on the transformer at various temperatures. The numbers in Table II. have been deduced from those in Table I. by assuming that the loss in the core is proportional to the square of the primary E.M.F., and presumably indicate the results that would have been obtained with 90 volts as the primary E.M.F. in each experiment.

The figures in Table II. show clearly that the loss in the core is greatly diminished when its temperature is elevated, *i.e.*, when heat is applied, and that the loss in the core is practically independent of the output. The result indicates that with the secondary open, and the primary at a difference of potential of 90 volts without heat applied, the core came to a temperature of 97°C., and dissipated 122 watts; while on the application of heat with the Bunsen burner the temperature was raised to 300°C., and only 72 watts were dissipated. Now, if we assume the changes in watts dissipated in the core to be approximately proportional to the changes in temperature that produced the same, we see by estimation that 79 watts would have been dissipated by the core at 270°C., while 80 watts were found to have been dissipated by it at that temperature when the

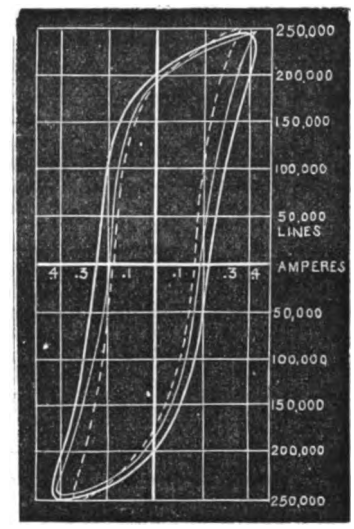

Fig. 1

secondary was closed, and gave an output of 32 watts. Thus, the secondary can be closed and 32 watts abstracted when the temperarure is raised 170deg., while at the same time the number of watts absorbed by the primary is diminished by 5.

The effect must be due to a decrease of the total amount of energy absorbed by the core through Foucault currents and hysteresis. The energy absorbed by eddy currents must be diminished by rise of temperature since the specific resistance is raised; as, however, for decided degrees of magnetism it is known that the permeability of iron increases with rise of temperature, experi-

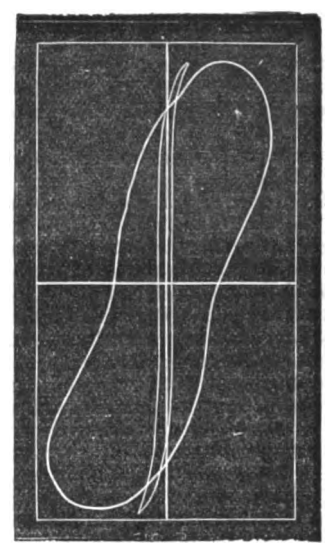

Fig. 2.

nents were made by Mr. A. Herschel to determine the effect of temperature on the hysteresis loss. A cast-iron ring was taken 12·3 cm. in diameter of section and 38·5 cm. in circumference, and wound with 80 turns of No. 8 wire. The highest temperature used was 360°C. The results show that for intensities greater than 3,000 lines the hysteresis loss diminished with rise of temperature, but for intensities smaller than 2,000 no alteration was observed. Now, if wrought iron behaves in a similar manner, the effects observed by Mr. Marks cannot be accounted for wholly or even partly by a diminution in the hysteresis loss, since great magnetic densities were not used. The effects are, therefore, to be entirely

* Abstract of Paper read before the American Institute of Electrical Engineers, June 17, 1890.

† See *Electrician*, January 10, and January 17th, 1890.

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ascribed to diminution of Foucault currents caused by the change of the resistance of the iron. A liberal estimate for the hysteresis of the core is 20 watts, whence the energy dissipated in Foucault currents by the core at 100°C. and 90 volts was 102 watts, while at 270°C. and 90 volts it was 60 watts. The percentage alteration in the number of watts wasted is very nearly the same as the percentage alteration of resistance for a range of 170°; so that, as it is fair to assume that the electromotive forces are the same for the two cases, and that the watts wasted vary inversely as the resistance, the coincidence affords a satisfactory confirmation.

An interesting feature about Mr. Marks' transformer is that the ratio of the primary and secondary turns was 3·2, while the ratio of the E. M. F. varied from four to eight. The very bad regulation here apparent exhibits in an exaggerated form the trouble it is so hard to get rid of in transformers to be used for incandescent lighting. A large number of the lines due to the primary are not

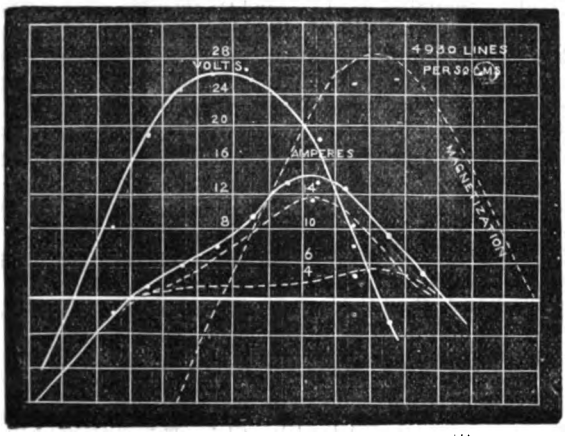

Fig. 3.

enclosed by the secondary, chiefly owing to the large space occupied by the windings. When a current flows in the secondary this effect is greatly increased, and Prof. Ryan shows how to use the curves to separate the active from the leakage magnetisations.

The effect of Foucault currents as distinguished from hysteresis is exhibited in a very striking manner in Figs. 1 and 2. In these curves the inner diagram represents the Ewing's card of static hysteresis, while the outer diagram represents what occurs when both hysteresis and Foucault currents are taken into account. Fig. 1 refers to the 10-light transformer already described (see *The Electrician*, January 10 and 17, 1890). In this case Foucault currents were absent, as the iron circuit was finely laminated and insulated. The outer diagram is deduced from the current and magnetisation curves. For Fig. 2 these curves are shown in Fig. 3.

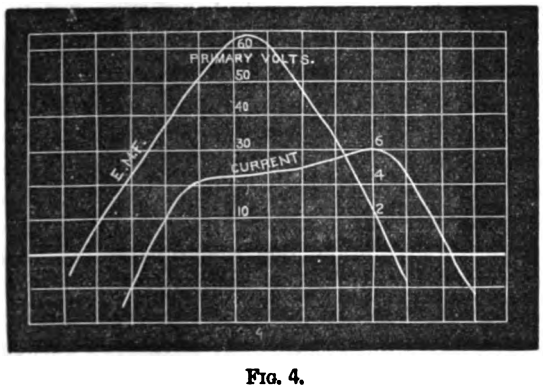

Fig. 4.

The ordinate of the current curve is taken as abscissæ of the new curve, while the corresponding ordinate of the magnetisation curve is taken as the new ordinate. The magnetisation curve is obtained from the E.M.F. curve (*see* Fig. 3) by a graphical process, which is not described.* The curves in Fig. 3 were obtained with 195 reversals per second from a cast-iron ring, 8·6cm. in diameter, and 2·7 square cm. in cross-section, wound with 200 turns of wire of negligible resistance. The lower broken current curve is that of the exciting current curve drawn in from the inner curve of Fig. 2. By subtracting this current from the one that was observed we obtain the upper broken curve, which is the current that exists to supply the Foucault current energy. The point to be noticed about the two extreme cases represented in Figs. 1 and 2 is that in each case the curve of current supplying the Foucault current energy is about one-eighth of a period behind the impressed E.M.F.

Figures 4 and 5 illustrate the extreme variation in the shape of the exciting current curve in going from the lowest to the highest degree of magnetisation. The former illustrates a transformer worked with low magnetic density in the core, while the latter shows the effect of compelling the magnetisation to be carried above the bend of the characteristic curve of the iron.

Messrs. Forhenbaugh and Sawyer, of Cornell University, made some determinations of the quantities of energy that are taken up per c.c. in wrought-iron cores of different degrees of lamination, at various degrees of magnetisation, and at different periodicities. The results are recorded in Table III.

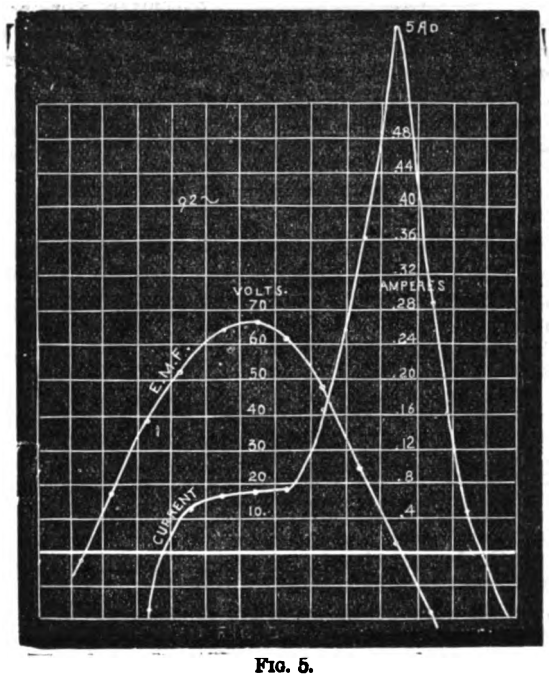

Fig. 5.

Table II.

Temp.	Loss in core.	Primary watts.	Secondary wat	
97·5°C.	122	122	0·0	
300°C.	72·	72	0·0	
270°C.	79 (estim.)	79	0·0	Corrected for
99°C.	117	131	24	rests of sec.
270°C.	80	116·7	36·7	

Primary, 90 volts ; 120 reversals per second.

Table III.

Coil. No. of wire B and S. G.	Area of coil, sq. cms.	Periodicity.	Magnetisation per sq. cm.	Loss watts per cubic cm.
12	5	169	5,300	·18
,,	,,	177	8,560	·46
,,	,,	177	11,130	·75
16	4·9	173	6,000	·14
,,	,,	175	9,430	·33
,,	,,	167	10,930	·43
,,	,,	93	7,250	·10
,,	,,	92	13,360	·41
,,	,,	45	13,000	·10
24	3·56	175	8,150	·19
,,	,,	53	8,760	·12
36	3·14	173	9,200	·16
,,	,,	173	14,900	·29
,,	,,	173	18,000 app.	·48
,,		96	10,700	·15
,,	,	92	17,800	·33
,,		47	18,000 app	·13
,, Cast iron	2·7	160	4,920	1·50

Diam. 3·5 × 2·54.

* For a description of what appears to be a similar method, *see* "Variation of Coefficients of Induction," by Dr. Sumpner. (*The Electrician*, Vol. XX., p. 713); also "The Use of the Integraph," by Ll. B. Atkinson (Vol. XXII., p. 702).

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The Electrician.

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COMPOUND WINDING.

The judgment of the Court of Session in the action of KING, BROWN AND CO., *v.* THE ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION brings to a conclusion a lawsuit which can be compared only with that of the EDISON AND SWAN ELECTRIC LIGHT COMPANY *v.* HOLLAND AND OTHERS. The former is of greater importance to the general trade, affecting as it does every dynamo maker, large and small; while the latter was the "biggest" patent case on record. Had the principle of compound winding been discovered, and the method of carrying it out in practice been invented by one of the skilled staff of the Brush Corporation, one would naturally regret that the rudimentary and half-forgotten experiments of VARLEY, who, through lack of resources or want of zeal had allowed his machine to sink into oblivion, should have stood between the worker and the worker's due. But the patent in question was one item of the "Brush System" which the Corporation had acquired. Whether BRUSH ever really imagined in 1878 that the addition of the "teazer" or shunt winding to a series-wound dynamo would have the effect of enabling it to supply a variable current at constant volts, is an abstract question into which the Directors cannot be expected to inquire. Whether the "permanent magnetic field" which BRUSH mentions in his eighth claim was to obviate the difficulty that "in dynamo-electric machines as ordinarily constructed no magnetic field is maintained when the external circuit is open, except that due to residual magnetism;" or whether the construction of a dynamo which could "do a large quantity

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of work" in electro-plating at one time, and "a small quantity" at another time, was a foreshadowing of distribution at constant potential, are also matters on which we cannot ask them to decide. The only real point is, the Brush Corporation have bought and paid for patent No. 2003 of 1878; can they justly claim royalties on all compound-wound dynamos? It is true that the teazer-wound dynamo gave a more useful characteristic than an ordinary series arc lighter; but, was this comparable for a moment with the compound-wound dynamo made by CROMPTON in the autumn of 1882, which ran glow lamps at constant volts for Mr. OCTAVIUS E. COOPE at Berechurch Hall?

In 1882 the patent was amended as to a few misprints and errors of spelling; and in February, 1886, the decks were cleared for action by extensive disclaimers. No definite movement was taken for some months, but, before the summer was over it was understood that the Brush Corporation intended to show fight. Several dynamo makers gathered round Messrs. CROMPTON AND Co., the acknowledged originators of constant-potential dynamos; and affidavits were obtained from eminent authorities who ranged themselves on either side, flatly contradicting each other, as is usual on such occasions. A good case was worked up; and each party, confident of victory, was at a loss to understand how their opponents could imagine they had a chance of success. But, one by one the supporters of the defendants withdrew, until the few firms who remained carefully computed the probable expenses of the case, and compared it with the amount they might expect to pay in royalties, allowing for extension of their output. The half-sovereigns per unit appeared to be the smaller burden, and the learned affidavits were pigeon-holed, the counsel were paid off, judgment in favour of the Corporation was agreed to in November, 1887, and licences were taken for compound winding. At a meeting of the Brush Corporation in March, 1888, the Chairman said, "We have every confidence in the strength of our position, and I am happy to say that that position has been recognised by all the leading makers in Great Britain. It is specially satisfactory to us that great firms like Messrs. CROMPTON and others, while they felt it their duty, of course, to oppose our claims, have behaved most honourably in this matter, and they took licences and agreed to pay royalties." In March, 1889, he said, "You know that we have a claim to have the controlling of the patents for compound winding of dynamos. That has been admitted by the English makers, and they are now paying us a royalty which amounts to a nice little income to us." These two statements looked very much as if the English makers had acknowledged that the claim was a just one. They did no such thing: they accepted the lesser evil. And here we must point out that the royalty was not a grievous burden; it fell practically on the purchaser; it was not in any way sufficient to divert orders for dynamos to Belvedere-road, nor do we suppose for a moment that such a diversion was intended.

Knowing the great expense of so important a lawsuit, considerable surprise was felt when Messrs. KING, BROWN, AND Co., of Edinburgh, in October, 1888, stated that the threat of the Brush Corporation with legal proceedings in respect of the manufacture of compound-wound dynamos had seriously affected their business, and accordingly applied for "the reduction" of the patent. We need not dwell upon the details of the case, as it is fresh in the memory of those of our readers who cared to study it. It is easy to criticise after the event; but it seems extraordinary that such great efforts should have been made to prove that VARLEY'S patent did not disclose sufficient information for enabling a compound-wound dynamo to be constructed. Whether VARLEY'S patent is sound is a matter of no importance, even to the inventor himself; as the patent, good or bad, has long since expired. Again, we were astonished at the amount of time spent over the commutator question—a mere side issue, and an accident, one of the few points that had not been expunged by the disclaimers from the comprehensive "omnibus" patent of BRUSH. The case was won fairly on the prior publication by VARLEY, and the issue was the fundamental one of compound winding. The Court of Appeal had a very clear idea of the case; the only two slips worth noticing are the designation of compound-winding as "a valuable electric appliance," and the suggestion that in a properly compounded machine "a nearly uniform current flows in the working field, notwithstanding variations in the quantity of work to be done." The work of CROMPTON, who was the first to place a self-regulating machine on the market, was not alluded to. CROMPTON not only brought out compound winding, but in getting up his case he brought out VARLEY, whose work had been completely forgotten. The Directors of the Brush Corporation have merely been doing their duty to their shareholders in endeavouring to make use of their property. The declared value of the patents of such Companies as this and of the Edison and Swan United form a serious portion of their load of capital; and in this respect the latter has to be congratulated on paying a respectable dividend on a capital which has never been reduced. Monopolies are a necessary consequence of the existence of patents. Ten shillings per unit is not much, but the extinction of one more tax will be welcome to the electrical trade.

ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 279.)

§ 6. **Central Station at Rome.**†—In very fully describing this station in 1889, Prof. G. Forbes‡ called it the "finest example of an alternating-current central station;" and it well deserves this commendation. Since it was described by him it has been increased by the addition of two more large 600 horse-power engines and dynamos, and has now a complement of plant equivalent to a total output of 24,000 16 candle-power incandescence lamps. The electric lighting of Rome is carried out by the gas company, which has enlarged its operations and exists under the denomination of the Società Anglo-Romana per l'Illuminazione di Roma col Gas ed altri sistemi. The Directors of this Company were wise and far-seeing enough to recognise the necessity of dealing with the electric light either as an ally or as a rival, and in the spring of 1886 commenced operations for the supply from the gas works of the electric current by the Ganz alternating system. The gas works at Rome are in the Via dei Cerchi, near the Tiber, under the shadow of the Mount Palatine, and occupy a position in the region of old Rome, near the site of the ancient Circus Maximus; and in forming the foundations of portions of the heavy dynamo machinery some of the old arches of the Circus were exposed. The plan and elevation of the station are shown in Figs. 17 and 18, from which the general disposition of the machinery and buildings can be seen. The Central Station plant

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† The author desires to acknowledge his indebtedness for the information on the details of this Central Station at Rome to Signor C. Pouchain, and also to Signor de Strens, Chief Engineer, who granted him every opportunity for examining the working of this interesting installation.

‡ "Some Electric Lighting Central Stations in Europe, and their Lessons." *Journal of Institution of Electrical Engineers*, Vol. XVIII., 1889, p. 172.

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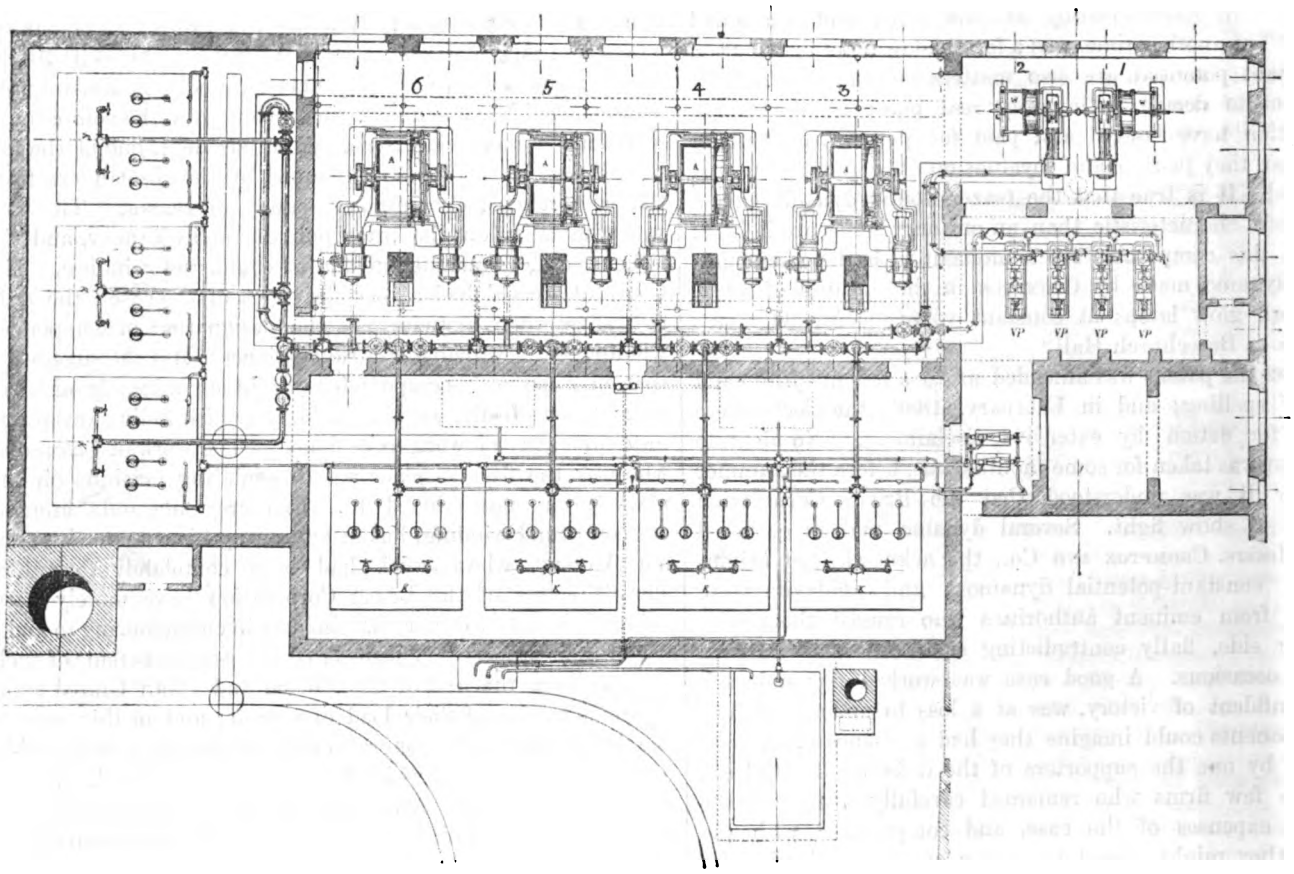

FIG. 17.—Plan of Central Station at Rome. Scale = 34 feet to 1 inch.

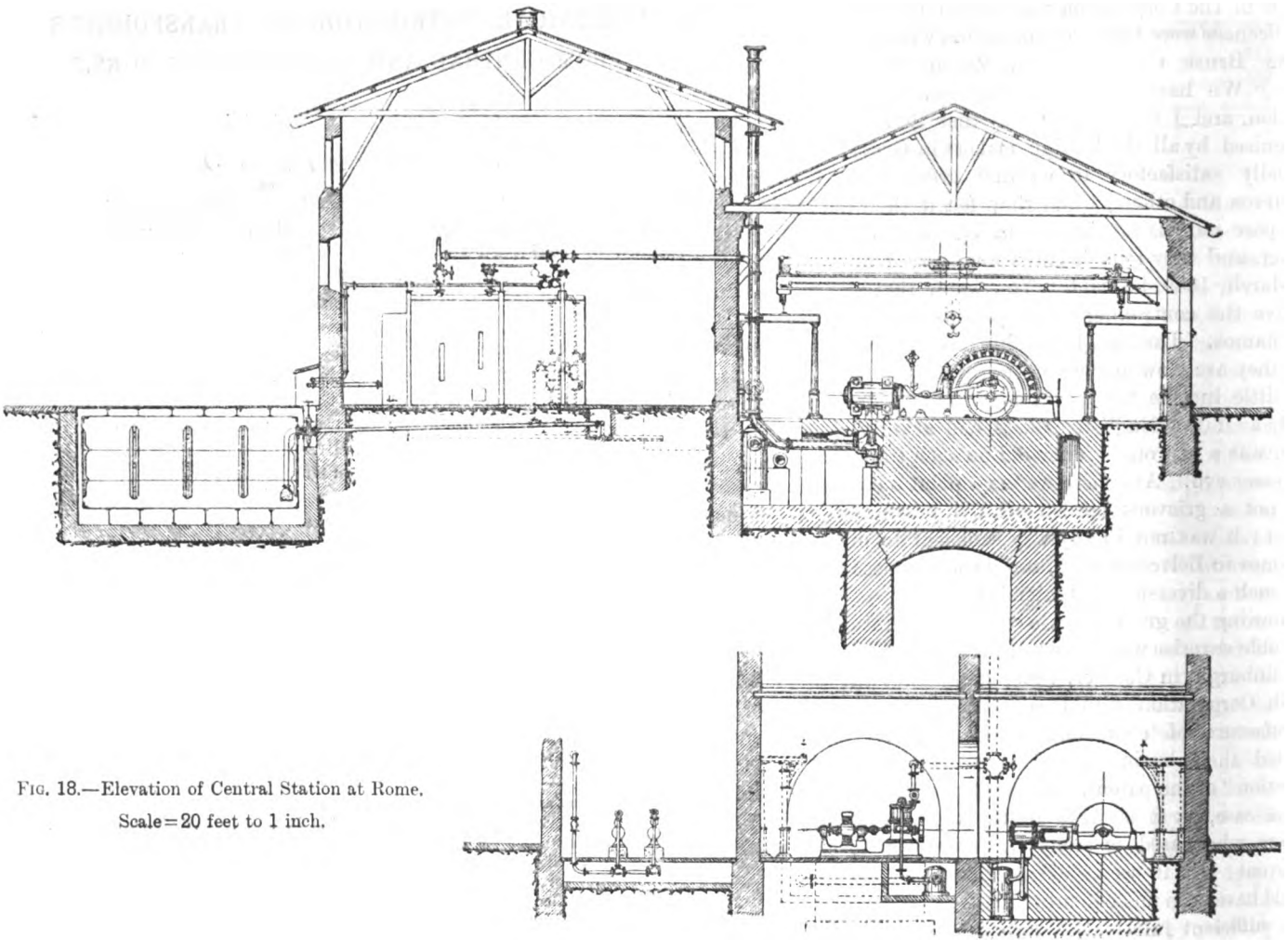

FIG. 18.—Elevation of Central Station at Rome.
Scale = 20 feet to 1 inch.

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consists of two similar small alternators of 80,000 watt-power, giving a maximum current of 40 amperes, at a pressure of 2,000 volts, which are coupled direct to engines of 125 horse-power, and of four large alternators of 320,000 watt-power, each giving a maximum current of 160 amperes at a pressure of 2,000 volts. The large dynamos are coupled direct to compound steam engines working up to 600 horse-power. The two smaller machines will be referred to as No. 1 and No. 2, and the four larger machines as No. 3, No. 4, No. 5, and No. 6, as shown in the plan. The four larger machines are not all similar in details. No. 3 and No. 4 are sister machines, and also No. 5 and No. 6; but the last two have many improvements not pre-

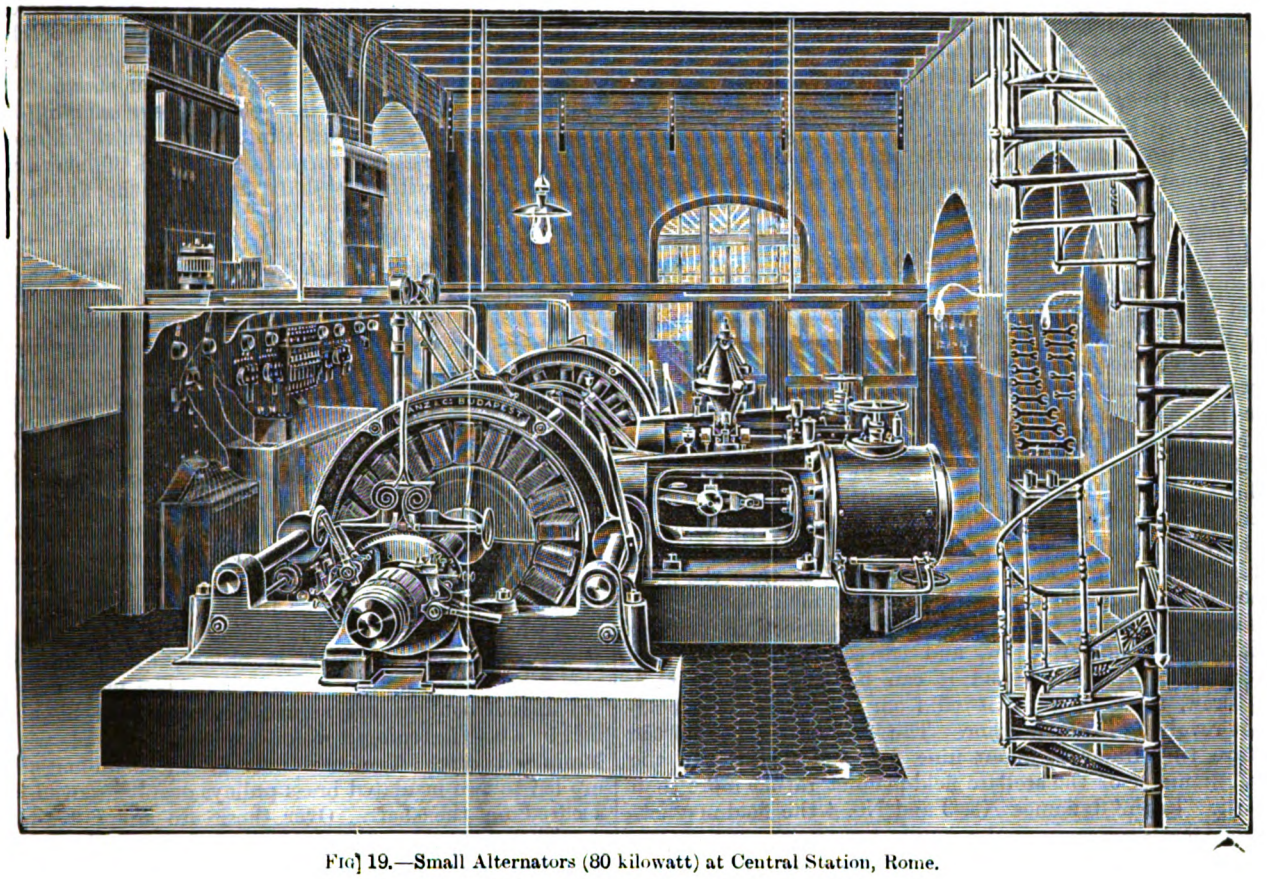

FIG. 19.—Small Alternators (80 kilowatt) at Central Station, Rome.

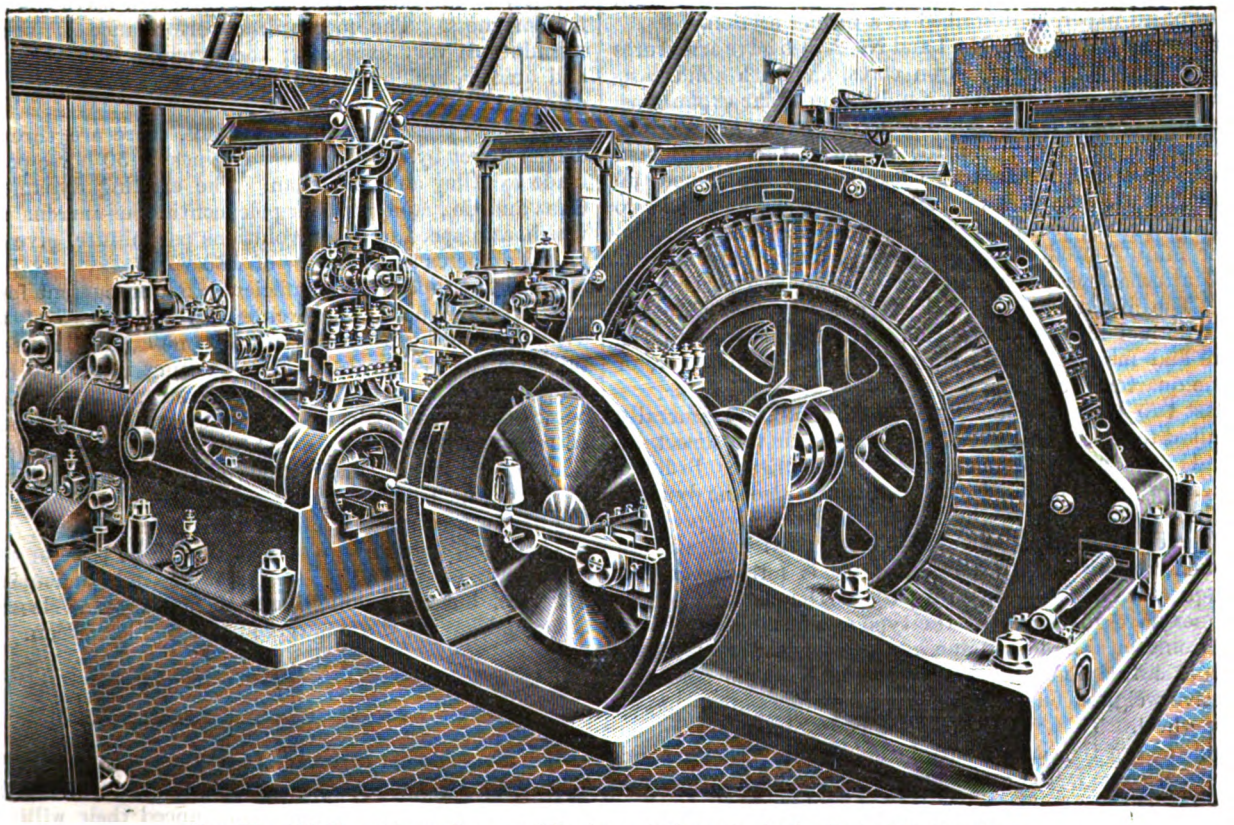

FIG. 20.—500 Horse-Power Compound Engine and Alternator in the Central Station, Rome.

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sent in the former two. Commencing our description with the first two, or smaller machines, these two dynamos were placed in position, and began to be used in the autumn of 1886. The general view of these machines is shown in Fig. 19. The engines are single-cylinder high-pressure engines by Gebrüder Sulzer, of Winterthur and Ludwigshafen. The speed is 250 revolutions per minute. These horizontal engines are built on a common bed-plate with the dynamo, and the revolving field-magnet of the dynamo forms the flywheel of the engine. The engines can be worked up to 150 horse-power. There are 20 coils in the fixed armature, and 20 poles in the stellate field-magnet, and in the armature all the coils are joined in series, each giving 100 volts, or 2,000 in all. In the field-magnets the coils are arranged in two series of 10 coils each, joined in parallel. The alternations are 5,000 per minute, or about 42 complete periods per second. These dynamos are auto-excited by a rectified alternating current and commutator, as above described, taking current from the secondary circuit of a field transformer, of which the primary coils are in connection with the armature of the alternator. The larger dynamos (placed in position and started in November, 1887), No. 3 and No. 4, are separately-excited alternators, coupled direct to 500 horse-power compound engines by Van den Kirchoffe, of Ghent. These last have elaborate expansion valve gear of Corliss type, and also centrifugal governors of the usual kind; they have also starting gear. The dynamo is placed between the high-pressure and low-pressure cylinder, so that the field-magnet is slung on the centre of the steel main shaft. The ring-shaped armature frame has massive projections or lugs on either side, supported by, and traversing in, guide bars like the bed of a lathe, and it can be traversed laterally by a screw, so as to move it off from and expose the field-magnet revolving in the interior. The interior diameter of the armature ring frame is about nine feet and a-half, and the over-all diameter of the stellate field-magnet rather more than nine feet. In the dynamos No. 3 and No. 4 the field-magnets have solid cast-iron cores and wrought-iron polar caps or projections; and these magnets, 40 in number, are placed round the periphery of an iron wheel keyed on the main shaft. The armature cores are built up of iron plates of thin sheet iron, with interposed paper, as described in a former section.

The two smaller dynamos, No. 1 and No. 2, also have armatures built in this way with divided iron cores, and with solid cast-iron field-magnet cores having wrought iron polar expansions. In the armature of dynamos No. 3 and No. 4 there are 40 coils, each generating 50 volts, and the whole of them are joined in series. In the field-magnets the 40 coils are joined up so that there are two series of 20 coils in each, and the two series are joined in parallel. The engines make 125 revolutions per minute, producing, therefore, an alternating current of 5,000 alternations per minute, or 42 complete periods per second. The armature coils will carry safely 200 amperes, but their normal load is about 160. The copper wire on the armature and magnet coils is six millimetres in diameter, or about one quarter of an inch.

The last two large machines, No. 5 and No. 6, are generally very similar to No. 3 and No. 4. They are driven direct by compound 500 horse-power engines by the Erster Brünner Maschinen Fabrik of Austria; and in this case also the dynamo field-magnet is slung as a flywheel in between the high-pressure and low-pressure cylinder. In order to give space for the stellate magnet and annular armature frame, a pit is formed between the high-pressure and low-pressure part of the engine. These last engines have governors of the type employed in the well-known Armington and Sims engine, in which the lead of the single eccentric is shifted and controlled by the outward movement of two massive weights contained in the interior of a pulley-shaped governor wheel. This governor is, for convenience, placed on the outside end of the main shaft of the engine. The general appearance of these last two 500 horse-power dynamos is shown in Fig. 20. These engines have been found to do their work remarkably well, and to govern steadily. The general principle of this centrifugal governor is that of causing a change of speed of the engine to alter the lead of the slide valve and so cut off the steam at different periods of the stroke. This is accomplished by carrying the valve eccentric not directly on the shaft, but on a sleeve which can be shifted in position on the shaft, so as to change the angle of lead of this eccentric from a position in which the eccentric axis is nearly parallel to the direction of the crank to one in which it is nearly at right angles to it. According to the degree of this angle of lead so will the steam be cut off almost at the beginning of the stroke, or at a point rather less than three-quarters of the stroke. The work done by the steam pressure can therefore be varied within wide limits. The shift of the sleeve carrying the eccentric is effected by a set of jointed rods, which are moved by a pair of heavy weights carried on the end of levers, which are carried round with the shaft either in the flywheel or in a special governor wheel. The outward movement of these weights, caused by the centrifugal action, is resisted by powerful springs in the governor wheel, and any change of speed operates directly to shift the lead of the valve. In these last dynamos, No. 5 and No. 6, the cores of the field-magnets, as well as the armature cores, are built up of laminated iron, as described in § 3. The bobbins of the field-magnets are formed of rectangular split zinc frames, about 15in. high and 20in. wide. They are wound over with the insulated wire, but more wire is placed at the bottom of the frame than at the top, and the finished bobbins have a slight taper from about 8in. to 6½in. in end width. The armature bobbins are shallow rectangular bobbins, wound on vulcanised fibre frames about 19in. long and 10in. wide and 2in. deep. Each bobbin has on it about 30 turns of highly insulated copper wire, about 6 mm. or ¼in. in diameter. The armature coils when slipped on to the laminated iron cores are kept in position by bobbin holders of bronze, which form a kind of skeleton frame clamped on the end. The more massive electro-magnet bobbins are secured by a similar bobbin holder, and by a bolt fastening it which traverses the whole width of the laminated core. The terminals of the field-magnet circuit are led to two insulated brass pulleys deeply grooved, which are secured on the shaft. Over these are slung flexible copper stranded cables, one end of which carries a pendant weight, and the other end of which is in connection with the excitor circuit. This affords an excellent, and yet perfectly flexible, contact surface, for the excitor current to enter and leave the alternator field-magnets. The mechanical performance of these latest machines is very excellent; the dynamos run very smoothly and quietly, and give no trouble by any heating or insulation defects.

To excite these four large dynamos, there are three excitors driven direct by Westinghouse engines of 50 horse-power each, made by Alley and Maclellan. The exciting dynamos are by Ganz and Co., and are four-pole continuous-current machines, which, at a speed of 375 revolutions per minute, give a current of 150 amperes and pressure of 180 volts.

Since 75 amperes is a sufficient exciting current for each of the large dynamos, one excitor can excite two of the large dynamos, and hence there is always one excitor in reserve. At full load the power absorbed in exciting is said to be 3½ per cent. of total absorbed power. The steam is provided from a plant of fourteen Babcock and Wilcox tubular boilers, each of 160 nominal horse-power. Coke is burnt in the furnaces. Four steam pumps, in addition to the usual injectors, supply water to the boilers. The total boiler horse-power is 2,240. The steam pressure is 120lbs.

There are, therefore, in this station three pairs of machines, each pair consisting of two similar independently driven dynamos, but all yielding a current at the same electromotive force, and having the same frequency of alternation.

(To be continued.)

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300 Horse-power Transmitted 175 Kilometres.—From the *Elektrotechnischer Anzeiger* we learn that the Allgemeine Elektricitäts Gesellschaft have announced their willingness, in conjunction with the Oerlikon Company, to transmit 300 horse-power from the Neckar at Lauffen to the Frankfort Exhibition, a distance of 175 km. (about 109 miles), on condition that an ordinary overhead cable, 5 mm. in diameter, connecting the two places, is provided free of cost.

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THE WORKING EFFICIENCY OF SECONDARY CELLS.*

By W. E. Ayrton, C. G. Lamb, E. W. Smith, and M. W. Woods, Associates.

(Continued from page 291.)

III.—*Automatic Current-Regulator.*

We think it possible that a neglect of the power that accumulators possess of drawing on a store of energy put into them in former chargings may have led experimenters to conclude that the normal efficiency of certain types of accumulators was greater than was really the case. To ascertain the *working efficiency* of the accumulators we were testing, it was clear that they would have to be charged and discharged alternately with a definite charging and a definite discharging current continuously for a much longer period than five days. And as this would be a very laborious operation if the current had to be kept constant day and night during this period by hand regulation, we proceeded to construct the automatic current-regulating device shown in Fig. 5.

A is a set of five accumulators under test, where B is a totally independent set of four used to provide the power for working the current-regulator. C is a platinoid strip of sufficiently large cross section and surface that no appreciable change of resistance can take place by the largest current—10 amperes—that flows through it in these experiments. D is a permanent magnet motor, the rotation of which in either direction turns the brass roller E F very slowly in one direction or the other, the pinion and toothed wheel of the motor, combined with the small grooved pulley on the toothed wheel shaft and the much larger grooved pulley on the roller, causing the angular motion of the roller to be about 1-500th of the angular velocity of the armature of the permanent magnet motor. The brass roller E F is electrically divided into two halves by the ebonite disc G, and little amalgamated discs at the ends of this roller turn with but little friction in mercury cups, H, I. Round each half of the roller are wound four bare platinoid wires of No. 26 gauge, and each about 4½ feet long. Their lower ends are soldered to the brass roller, and their upper ends to the brass bar, J K, small spiral springs (not shown in the figure) being introduced to keep the wires taut. The rod J K is held up by a cord which passes over two pulleys, and to the end of which is attached the weight L. An electric current, entering at H, follows the path H, E, J, K, F, I, the path being longer or shorter depending on the amount of the platinoid wires wound on the two halves of the brass roller. M is a solenoid, being, in fact, the coil of an A. and P. ammeter, on the axis of which a rod, P Q, was very delicately poised by its being supported by four very fine wires of No. 40 gauge, and each about one foot long. Two of the wires N, on a plane at right angles to the path, joined together where they were connected with the rod at Q, but spread out at the top, and similarly O consisted of two wires. Thus, while the rod P Q had great freedom of motion along its axis, it could not wobble sideways. This rod consisted of two pieces of brass at its ends, but the middle shaded portion was the well-annealed soft iron tubular core of the ammeter. A current passing round the coil M sucked in the core more or less against the pull of the antagonistic spiral spring P P'. This spring was made of platinoid wire of No. 26 gauge, wound round a ¾-inch mandril, and when pulled out in position it had about 30 turns to the foot, and was over four feet in length. One end of the spring was attached to the rod at P, while the other, P', was fastened to a fine thread, which could be wound up more or less round a small roller and the tension of the spring very delicately adjusted.

At first the elasticity of this spring was not perfectly constant, but after about one month's use the pull it exerted when stretched to a given length became wonderfully definite, and the core P Q could be adjusted, so that for a current of exactly 9 amperes flowing round the solenoid M the projection at P remained midway between the contacts R and S without touching either. But on the current flowing round the solenoid M becoming very slightly greater, or very slightly less, than 9 amperes, the platinised projection of the rod at P made contact with either the platinised piece R or S. The permanency that the spring eventually attained was so great that even when the apparatus had not been in use for two or three weeks one had only to close the circuits to start the regulator, and no fresh adjustment whatever of this spring was necessary to ensure that the current would be kept absolutely constant at 9 amperes. This spring has, however, now gone the way of most bare fine platinoid wire, of breaking up into pieces.

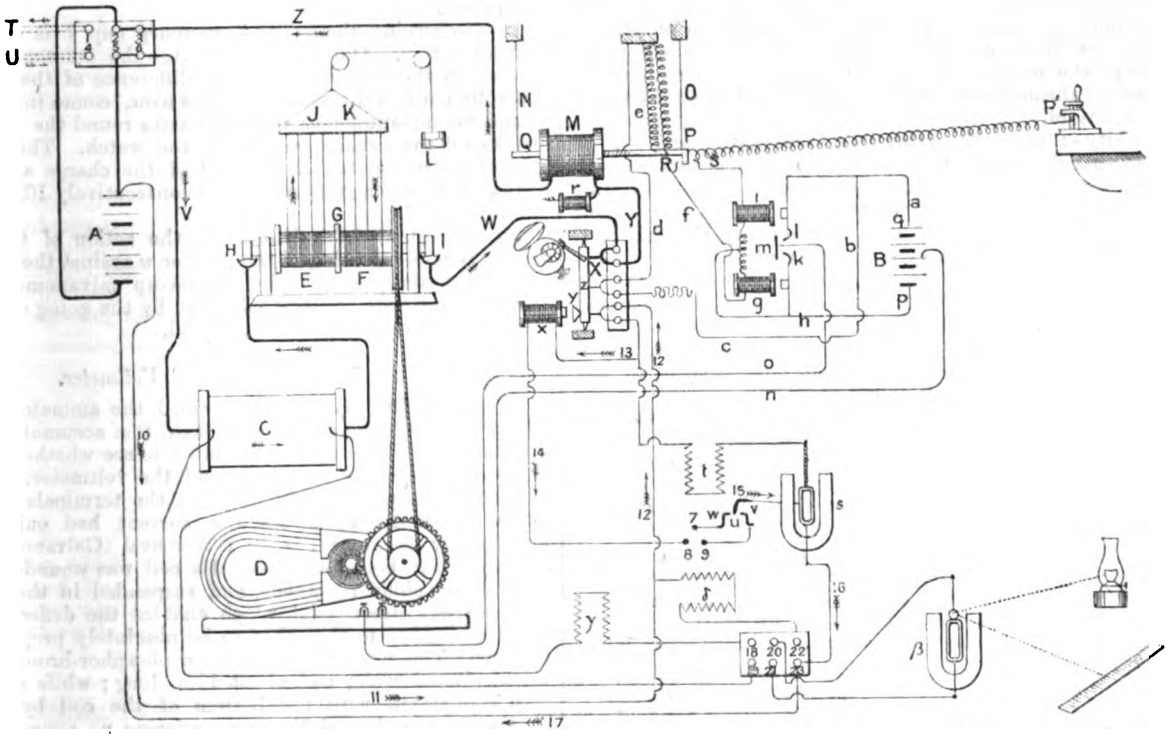

Fig 5.—Automatic Current Regulator and Automatic Interruptor for Breaking the Charging and Discharging Circuits.

When the cells A under test were being charged by means of a set of accumulators, not shown on the figure, but attached to the leads T and U, three copper bridge-pieces were put in to connect the mercury cups 4 to 5, 2 to 6, and 1 to 3 respectively; whereas when the test cells were being discharged two copper bridge-pieces connected the mercury cups 2 to 3 and 5 to 6. The current passed, of course, one way through the cells A in charging, and the other way in discharging; but in both cases a positive current flowed, as indicated by the arrows, through the thick lead V, the platinoid strip C, through H, E, J, K, F, I, through the thick lead W, the thick lead Y, the solenoid M, and the thick lead Z. As already explained, if the currents through this circuit exceeded in the very least 9 amperes, the core P Q was sucked into the solenoid M until P made contact with R; whereas if the current fell in the least below 9 amperes, P Q was pulled backed by the spring P P' until P made contact with S. In the former case a small auxiliary cur-

* Read at the Extraordinary General Meeting of the Institution of Electrical Engineers at Edinburgh, on July 16th, 1890.

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rent from the accumulators B follows the course *a*, *b*, *c*, *d*, through the spirals *e*—several in number, so as to carry the current, but made of extremely fine wire, so as to oppose practically no resistance to the free motion of P Q—then from P to R, through *f*, the electro-magnet *g*, and through *h*, back to the other pole of the battery B. If, instead, P be in contact with S, then the current from the auxiliary accumulators B passes from P to S through the relay electro-magnet *i*, instead of through the relay electro-magnet *g*. In the former case the spring tongue *k* is attracted so as to make contact with M (M being in reality a mercury cup into which dipped a platinum point with which *k* was tipped), and in the latter case the spring tongue *l* is attracted so as to make contact with *m*. If *k* makes contact with *m*, a positive current commencing from the middle of the accumulators B follows the path *n*, the motor, through *o*, *m*, *k*, and back to the end of the accumulators *p*; whereas if *l* makes contact with *m*, a positive current follows the path *q*, *a*, *l*, *m*, *o*, the motor, through *n*, and back to the middle of the cells B.

Accordingly, then, as P makes contact with R or with S, a current is sent one way or the other through the armature of the permanent magnet D, and the roller E F is turned around one way or the other so as to unwind, or wind up, more of the wire and automatically alter the resistance in the circuit. Although the whole apparatus was home-made, and looked very rough, it was able to automatically keep the current constant to 1 part in 600 for days at a time.

As the charge was effected with 9 amperes and the discharge with 10, a shunt, *r*, exactly nine times the resistance of M, was connected across M during the discharge, and as the automatic regulator kept the current through M constant at 9 amperes, it kept the current through the circuit constant at 10 when the shunt *r* was attached to M.

The necessity of using the relay electro-magnets *g* and *i* arose from the fact that the only suitable permanent magnet motor which was at our disposal was a laboratory hand magneto Gramme machine which required a current of about 1 ampere to work it; and to obtain great sensibility the contacts between P and R or P and S had to be too slight to carry such a current.

It was very interesting to watch the regulator, since the armature of the motor was almost always in motion, now making half a turn one way, now one turn the other. It may be mentioned that one turn of the motor armature shortened or lengthened each of the platinoid wires by about $\frac{1}{6\frac{1}{2}}$ of an inch—that is, by less than the $\frac{1}{3000}$ of its whole length.

At first all sorts of plans were tried for keeping clean the surface of the mercury in the mercury cap *m*; but alcohol floated on the mercury failed because it dried up, water was electrolysed, oil was carbonised, and a long conducting point adhered to each of the platinum points *l* and *k*, and the auxiliary accumulators B were short-circuited. In despair we left the surface of the mercury completely exposed to the air, and were surprised to find that that answered perfectly: a thickish layer of mercury and mercurous oxide formed on the top, but the platinum wires easily forced their way through and always made good contact.

To avoid, however, all risk of accidents, cut-outs were introduced into various parts of the circuit: and to prevent the motor overwinding the platinoid resistance wires on the roller E F and breaking them, should the current in the main circuit accidentally become much too small, as well as to prevent the motor unwinding the wires too far off the roller should the current become much too large, safety keys (not show in the figure) were provided. If the rod J K were drawn down dangerously low, or allowed to go up too far, it touched one or other of the safety keys and broke the electrical circuits.

IV.—*Automatic Interruptor for Breaking the Charging and Discharging Circuits.*

As it was extremely important that both the charging and discharging circuits should be broken at the exact moment when the potential difference in its rapid variation passed through certain specific values, and as in a long course of experiments, lasting for several months, it was quite possible that occasionally no one of the observers would be present at the exact moment, we arranged an interruptor to break the circuit automatically when the potential difference in charging reached 2·4 volts per cell, or 1·6 volts per cell in discharging. The automatic interruptor was arranged thus: *s* is a D'Arsonval galvanometer, the coil of which, wound with platinoid wire of 154 ohms resistance, is joined in series with a resistance box, *t*, as a shunt to the accumulators A under test. Electric connection was made with the bottom of the coil by means of a fine spiral spring too thin to introduce any controlling moment, while above the coil was suspended by a phosphor-bronze strip 1-1,000th inch thick, 12-1,000ths broad, and 1¾in. long. This strip had seven twists put into it by means of a head moving in a tight collar, the coil being prevented from turning by a pointer, *u*, attached to the framework of the coil coming into contact with the stop *v*. The thin phosphor-bronze strip being very thin, it had very little torsional rigidity, and being set up as described, this instrument acted as a "set-up voltmeter"—a type of instrument proposed some years ago by Prof. Perry and one of the authors of the paper for measuring with great accuracy a very small change in a potential difference. With a definite adjustment of the resistance in the box *t*, the platinum-tipped pointer *u* remains in contact with the stop *v* for all potential differences between the terminals of the accumulators A less than 2·4 volts per cell. When the potential difference reaches this value the pointer at once leaves the stop *v*, moves over through an appreciable distance, and makes contact with the platinum-tipped stop *w*. With another definite adjustment of the resistance in the box *t*, the pointer *u* remains in contact with *w* for all potential differences between the terminals of the accumulators A greater than 1·6 volts per cell, but the moment this value is reached the pointer moves away from *w* and makes contact with the platinum-tipped contact-stop *v*.

When charging, a copper bridge-piece connects the mercury cups 7 and 8, and when, on the potential difference at the terminals of the accumulators A reaching 2·4 volts per cell, the pointer *u* passes over and makes contact with *w*, an instantaneous small current is sent by the accumulators A through the electro-magnet *x*, which attracting the armature *y* downwards, tilts the spindle *z*, and thereby lifts X and the other two contact-forks out of the three sets of mercury cups, thus breaking *all* the circuits. The tilting of the spindle *z* also brings a camel's-hair brush into contact with the balance of a watch, and stops it at the moment the charging is completed.*

In discharging the cells A mercury cup 7 is connected to 9 instead of to 8. During the discharge the pointer *u* rests against *w*, and on the terminal potential difference of the cells falling to 1·6 volts per cell the pointer moves over, comes into contact with *v*, and an instantaneous current passes round the electro-magnet, breaks all the circuits, and stops the watch. The course of this instantaneous current at the end of the charge and discharge is indicated by the arrows numbered consecutively 10, 11, 12, 13, 14, 15, 16, and 17.

To prevent any sluggishness in the action of this interruptor from a possible sticking of the pointer *u* against the contact-stops *v* or *w*, the pedestal supporting the set-up galvanometer *s* was kept in a constant state of slight vibration by the going of an American clock that was placed on this pedestal.

V.—*Ammeter and Voltmeter.*

There remain only to be described the ammeter, by means of which the current passing through the accumulators could be measured from time to time, in order to see whether the automatic regulator was doing its duty; and the voltmeter, for frequently measuring the potential difference at the terminals of the accumulators, A, under test. As the current had only to be very occasionally measured, one D'Arsonval Galvanometer, *β*, was employed for both purposes. Its coil was wound with platinoid wire of 52 ohms resistance, and suspended in the way that has been already described,† which enables the deflection from one end of the scale to the other to be absolutely proportional to the current. The top suspension was a phosphor-bronze strip $\frac{1}{1000}$in. thick, $\frac{1}{16\frac{1}{2}}$in. wide, and about 1¾in. long; while electric contact was maintained with the bottom of the coil by means of an extremely fine A. and P. spring, offering no appreciable torsional rigidity. The permanent magnets employed belonged to an old magneto machine, and into the cylindrical space between their poles, in which the Siemens armature formerly turned, was put a coil made of the right shape to suit the curved ends of the magnets without it being necessary to employ any soft iron pole-pieces. Experiment showed that the deflection right across a scale 2ft. 9in. long. the zero for no current being at one extreme end, was rigorously proportional to the current—a result which, as has been already pointed out, is very far from being obtained with D'Arsonval galvanometers as usually constructed.

When it was desired to measure the current passing through the accumulators, A, a rocking switch was turned so as to connect mercury cup 18 to 20, and 19 to 21; whereas when it was the potential difference at the terminals of the accumulators that was to be measured, the rocking switch was turned so as to connect mercury cup 20 to 23, and 21 to 22. In the former case, with a resistance of 264 ohms on the resistance box *γ*, a current of 10 amperes passing through the cells and platinoid strip C produced a deflection of 500 scale divisions, or 50 divisions per ampere; while, with a resistance of 71,570 ohms in the resistance box *ε*, a potential difference of 10 volts at the terminals of the five accumulators A under test produced the same deflection; so that 50 divisions corresponded then with 1 volt.

* As it was undesirable to risk an expensive watch, we purchased one of the watches that could be then obtained in St. Paul's Churchyard for 3s. 5½d. This watch was very substantial, had a very strong hair-spring which could not be easily damaged, and was an excellent time-keeper—far superior to many watches of a far more expensive character.

† See Paper on "Galvanometers," *Phil. Mag.*, July, 1890.

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VI.—*Results obtained with Automatic Apparatus.*

Many preliminary experiments having been made with the automatic apparatus, we succeeded in making it work quite satisfactorily by the beginning of May, 1889, and it was adjusted to charge five accumulators, A (Fig. 5), with a steady current of 9 amperes until the potential difference reached 2·4 volts per cell, and to discharge them with a steady current of 10 amperes until the potential difference fell to 1·6 volts per cell. After 12 days and nights had been spent in continuous charging and discharging, the cells reached a normal state, the time rise of potential difference in charging and the time fall in discharging being at length repeated over and over again, so that when the time curves were drawn for the successive charges they exactly coincided, and so for the discharge curves. The areas of these curves—reckoned, of course, from the zero of potential difference, which is much below the figure as here show—may thus be said to give the "working watt-hours" for charge and for discharge when the charge and discharge are effected between limits of 1·6 and 2·4 volts per cell. Fig. 6

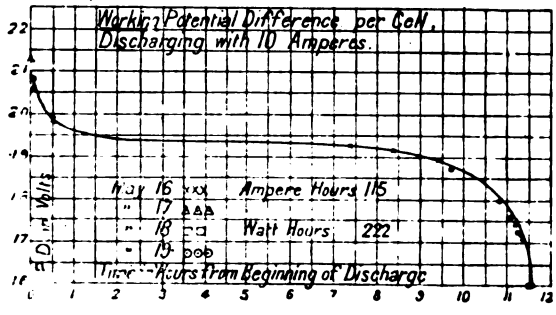
Working Potential Difference per Cell.
Discharging with 10 Amperes.
Volts
May 16 xxx Ampere Hours 115
" 17 ΔΔΔ
" 18 □□ Watt Hours 222
" 19 ○○○
Time in Hours from Beginning of Discharge

Fig. 6.

shows the discharge curves obtained on May 16th, 17th, 18th, and 19th, the points for each of the discharges being indicated by points differently marked as stated on the figure; and Fig. 7 shows the intermediate charge curves obtained on May 17th, 18th, and 19th. Integrating these curves, we find—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
115	221·8	117	256·2	98·3	86·5

Soon after this very concordant set of results was obtained, the time of charging, which had remained steadily at 13 hours from the commencement of May, began to increase to 15½ hours, while the time of discharge only increased half an hour—that is, to about 12 hours. At first we thought that we had been trying to charge the

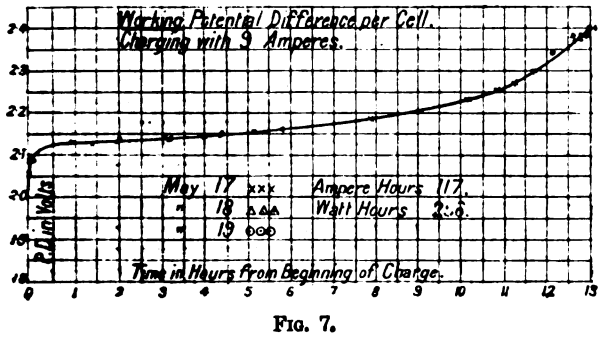
Working Potential Difference per Cell.
Charging with 9 Amperes.
Volts
May 17 xxx Ampere Hours 117.
" 18 ΔΔΔ Watt Hours 256.
" 19 ○○○
Time in Hours from Beginning of Charge.

Fig. 7.

cells too much, so we stopped the charging when the potential difference per cell rose to 2·35 volts; but the time of charging still continued to increase, until at last it rose to 24 hours, the time of discharge still remaining about 12 hours. On again reducing the potential difference limit on charging, the potential difference per cell now refusing to rise to 2·35 volts, both the times of charging and discharging became very irregular, and at length the time of charging suddenly fell to 10 hours and the time of discharging to 6. On carefully examining the plates, they were found to have badly scaled, and to have suddenly become partially short-circuited; they were therefore carefully scraped, and the mud allowed to settle at the bottom, where, in consequence of the special construction of the 1888 cell, it could remain without short-circuiting the plates. Only a few plugs fell out in this operation. This sediment was afterwards weighed and analysed, showing a composition that will be referred to in Section VIII., on the Chemical Action.

We now concluded that we had been running the cells too low, and we therefore decided to stop the discharge when the potential difference per cell fell to 1·8 volts, retaining the higher limit of 2·4 volts per cell to limit the charge. It is interesting to notice that Dr. Louis Duncan and Mr. H. Wiegand, in their paper on "The Inherent Defects of Lead Batteries," read before the American Institute of Electrical Engineers, and which we saw for the first time at the end of June, 1889, reprinted in the *Electrical World*, come to exactly the same conclusion—that the discharge should be terminated at 1·8 volts per cell, otherwise there is a formation of white lead sulphate, and a rapid depreciation of the cell. From what we have since seen, we think that the discharge should be stopped even still sooner—when the potential difference per cell has reached 1·9, or 1·85 volts at the lowest.

(To be continued.)

ELECTROLYTIC SEPARATION OF METAL AT THE FREE SURFACE OF A SALT IN SOLUTION.*

BY DR. J. GUBKIN.

1. When a current of electricity passes from the solution of a salt into a vapour or a gas, electrolytic separation of the metal must occur at the surface of the liquid. At the suggestion of Herr Warburg I have made one or two experiments to determine how the separation of metal takes place in such a case.

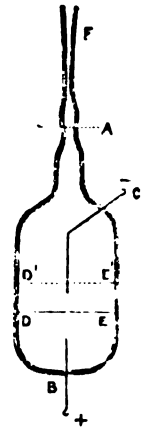

Fig. 1.

2. It is best to render the space above the liquid free of air. For this purpose the apparatus shown in Fig. 1 was used. It consisted of a glass vessel in which two platinum wires, B and C, were sealed—B being plated electrolytically with the metal to be separated from the solution. The latter was introduced to the level D′ E′ and boiled for about ten minutes until its surface had sunk 4 or 5 mm. below the point of the wire C. While the vapour was still escaping the vessel was closed at F with shellac; and, after cooling, the neck was melted off at A. The apparatus then appeared sufficiently free from air.

In order to reduce the vapour pressure, the lower part of the vessel was placed in ice, the upper part being freed by warming from any liquid that still clung to it.

A battery of 1,000 Planté accumulators was then connected—the positive pole with B, the negative with C; upon which there appeared at C the well-known negative glow.

3. When the vessel contained nitrate of silver, the following was observed:—Soon after putting on the current a small round disc of bright silver was formed just underneath C. As the disc increased in diameter it darkened at the centre, and there was formed upon it a series of light and dark concentric rings, which were sometimes coloured—some of these showing radial markings which gave them the appearance of divided circles. The disc did not sink, provided the apparatus was kept from shaking.

4. With a solution of zinc sulphate there was no separation of metal to be seen; but on looking at the surface D E from below,

* *Wied. Ann.*, 32, p. 114, translated by Mr. A. P. Chattock, and communicated by Dr. Lodge, Secretary of the Electrolysis Committee of the British Association.

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white flocculent masses of zinc oxide were visible, slowly sinking through the liquid. The zinc on separation by the current was thus immediately oxidised.

5. For experiments with a solution of platinum chloride the apparatus in Fig. 2 was used; in this the chlorine was collected over B.

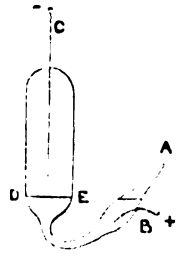

FIG. 2.

A short time after closing the circuit there was visible just opposite C a small lump of dead black platinum. On stopping the current this floated to the side of the vessel, but returned to its original position just opposite C, when the current was again started, thus preventing the formation of a fresh lump. Very probably this phenomenon was due to electric forces.

6. These experiments may also be carried out in air by means of an induction coil. The liquid is contained in a funnel, as in Fig. 3,

FIG. 3.

and the discharge at "break" furnishes the necessary current, the spark gaps between the solution and the cathode being arranged to prevent a discharge at "make" from taking place. In this manner experiments with silver, zinc, and copper solutions were carried out, with results substantially the same as those described above; except that here the space flowed through by the current, and, consequently the diameter of the silver disc, was smaller than before. The concentric rings were, however, clearly visible.

A PROOF OF MAXWELL'S THEORY OF RESIDUAL CHARGES.*

BY H. MURAOKA.

According to Maxwell's theory no residual charge can appear in a perfectly homogeneous dielectric, whereas parallel layers of various dielectrics, each homogeneous in themselves, will give a residual charge, provided none of them is a perfect insulator. The first part of the theory has been already established by the researches of Rowland and Nichols, Hertz, Arons, and Dieterici. The author of this paper succeeded in proving the truth of the second part by Dieterici's method. He superposed layers of two of the dielectrics, paraffin oil, petroleum, castor oil, oil of turpentine, xylol, paraffin and air, and with some exceptions found considerable residual charges. The exceptions occurred when two good insulators or two miscible fluids were chosen. When one dielectric is soluble in the other, as for instance paraffin in xylol, the residual charge disappears. Maxwell's view would lead one to expect a residual charge where the dielectric consists of microscopically minute particles of different substances. This, therefore, cannot be the nature of the solution.

* Wiedemann's *Annalen*, Bd. 50, Heft 6, 1890.

THE ELECTRIC LIGHTING OF BRIGHTON.

We were able to give in our issue of the 11th inst. the successful tenders for the electric lighting of the Borough of Brighton. Below will be found the complete list of tenders sent in:—

For Section A. (Buildings.)

Mr. G. G. Garbutt	£5,413	9	5
Messrs. J. Longley and Company	4,236	0	0
Mr. J. T. Chappell (accepted)	3,989	0	0

For Section B. (Boilers, &c.)

The Brush Electrical Engineering Company (Limited)	£3,366	0	0
Crompton and Company (Limited)	3,150	0	0
Messrs. Fraser and Fraser	2,767	0	0
Messrs. Wm. and John Yates (accepted)	2,734	0	0
Messrs. Sharp and Kent	2,715	0	0
Messrs. James Johnston and Company	2,545	0	0
Messrs. Alfred Anderton and Sons	2,530	0	0
Messrs. Nicholson and Jennings	2,378	4	0

For Section C. (Dynamos, &c.)

Latimer, Clark, Muirhead, and Co.	£11,946	0	0
The Electrical Construction Corporation (Limited)	11,595	0	0
Siemens Brothers and Company (Limited)	11,265	0	0
The Brush Electrical Engineering Company (Limited)	11,258	0	0
Messrs. Charlesworth, Hall and Co.	11,188	0	0
Siemens Brothers and Co. (Limited)	11,040	0	0
Messrs. Johnson and Phillips	10,496	10	0
The Electrical Construction Corporation (Limited)	10,022	0	0
Siemens Brothers and Co. (Limited)	9,950	0	0
The Gulcher (New) Electric Light and Power Co. (Limited)	9,800	0	0
Siemens Brothers and Co. (Limited)	9,725	0	0
The Electrical Engineering Corporation (Limited)	9,586	0	0
Crompton and Co. (Limited)	9,455	0	0
The India Rubber, Gutta Percha and Telegraph Works Co.(Ld.)	9.164	0	0
Messrs. Sharp and Kent (less various extras) (accepted)	7,997	10	0
Messrs. Nicholson and Jennings	7,512	4	0
Messrs. Sharp and Kent	6,975	0	0

For Section D. (Batteries.)

Siemens Bros. and Company (Limited)	£8,000	0	0
Crompton-Howell, E. L. Company (Limited)	7,440	0	0
Crompton and Company (Limited)	7,336	0	0
Mr. J. A. Timmis	6,262	12	0
Siemens Bros. and Company (Limited)	5,825	0	0
Messrs. Sharp and Kent	5,530	0	0
The Brush Electrical Engineering Company (Limited)	5,504	3	0
The Electrical Construction Corporation (Limited) (accepted)	5,242	0	0
Messrs. Johnson and Phillips	5,000	0	0
Siemens Bros. and Company (Limited)	5,000	0	0
Messrs. Drake and Gorham	5,000	0	0

For Section E. (Instruments.)

The Brush Electrical Engineering Company (Limited)	£2,197	14	0
Siemens Bros. and Co. (Limited)	1,830	0	0
The Electrical Engineering Corporation (Limited)	1,356	0	0
Messrs. Sharp and Kent (accepted)	1,180	0	0
The India Rubber, Gutta Percha, and Telegraph Works Co.(Ld.)	1,075	0	0
The Electrical Construction Corporation (Limited)	1,062	10	0
Crompton and Co. (Limited)	1,045	0	0
The Woodhouse and Rawson Electric Manufacturing Company (Limited)	685	0	0

For Section F. (Cables.)

Siemens Brothers and Company (Limited)	£11,950	0	0
Messrs. Johnson and Phillips	11,436	0	0
MM. Felten and Guilleaume	10,150	0	0
The Fowler-Waring Cables Company (Limited)	10,124	10	0
Crompton and Company (Limited)	10,090	0	0
The India-Rubber, Gutta Percha and Telegraph Works Company (Limited)	9,920	0	0
Messrs. Sharp and Kent	9,595	0	0
The Brush Electrical Engineering Company (Limited)	9,300	3	6
Callenders Bitumen Telegraph and Waterproof Company (Limited) (accepted)	9,096	0	0
Laurence, Paris and Scott (Limited)	7,284	0	0

For Section G. (Street and other Boxes.)

MM. Felten and Guilleaume	£1,650	0	0
The Fowler-Waring Cables Company (Limited)	990	0	0
Siemens Brothers and Co. (Limited)	825	0	0
The India Rubber, Gutta Percha and Telegraph Works Co.(Ld.)	790	0	0
Messrs. Sharp and Kent	535	0	0
Crompton and Co. (Limited)	503	0	0
The Brush Electrical Engineering Company (Limited)	448	17	0
Callenders Bitumen Telegraph and Waterproof Company (Limited) (accepted)	437	0	0
Laurence, Paris, and Scott (Limited)	300	0	0

For the whole of the Work.

The House-to-House Electric Light Supply Company (Ltd.)	£46,250	0	0

Three other tenders were received too late, and were not opened.

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THE BIRMINGHAM BRISTOL-ROAD ELECTRIC TRAMWAYS.

Major-General Hutchinson, Board of Trade Inspector of Tramways, last week made a formal and official inspection of the new electric tramways which the Birmingham and Central Tramways Company have laid along the Bristol-road from Navigation-street, in the city of Birmingham, to Bournbrook on its outskirts. Major-General Hutchinson, accompanied by Major Cardew, Mr. Joseph Smith (chairman), Mr. W. J. Carruthers-Wain (managing director of the Central Company), Mr. H. Lea (electrical adviser to the City Council), Mr. J. Kincaid and Mr. E. Pritchard (engineers), Mr. A. Dickenson (consulting mechanical engineer), Mr. T. Parker (representing the Electrical Construction Corporation), together with some twenty other passengers, made a trip of about three miles to Bournbrook. While running at full speed, the car was stopped suddenly with the view of testing the brake. The car pulled up in its own length; but this did not satisfy the inspector. On the outward journey the bogie on which the motor was fixed was the foremost, but on the return journey the inspector ordered the position to be reversed and the car to be driven forward. The passengers were also requested to sit as far as possible at the rear of the car. This was done in order that the efficiency of the motor might be tested under the most difficult conditions. On the decline between Wellington-road and Belgrave-road the car was again pulled up to test the brake, with the capacity of which the inspector was still not satisfied. At the curve into Navigation-street the speed was increased, and the car passed safely over at a great pace. The brake was again applied, and the car pulled up within a length. After three further trials of the brake Major-General Hutchinson suggested two or three alterations in the appliance with a view to increase its efficiency, and the Chairman of the Company promised that these should be carried out. The inspection—which in every respect, save the brake, had passed off in a completely satisfactory manner—then terminated.

The old horse-line was of 4ft. 8½in. gauge, and had fallen into a very bad state. The line has now been reconstructed throughout on the same gauge and in the same manner as the rest of the Central Company's line in and around Birmingham. The rails are of steel, in girder sections, 6in. deep with a 7in. flange, and weigh 92lb. to the yard. They are secured in the most solid manner, with steel fish-plates 2ft. long by 6½in. bolts, and the points are of Siemens open-hearth steel. The rails are set in a bed of Portland cement concrete, 6in. thick, and the area between the lines and for a space of 2ft. 6in. outside the metals paved with wood blocks with an edge of serrated granite setts to bind with the macadam of the rest of the roadway.

The depôt for the section is at the Bournbrook terminus, standing about 80 yards away from the main line, and covers an area of three-quarters of an acre. The buildings comprise traffic office, engineer's office, men's room, stores, switch room, accumulator room, lead-melting store, machine and fitting shops, engine and boiler houses, coal store, and large car sheds and charging station The charging station, 75ft. long and 63ft. wide, where the spent batteries are removed and replaced by freshly-charged cells, forms the front of the depôt. Lines run through it into the car shed, which is of uniform width with the charging station and 100ft. long, and underneath the lines are pits to facilitate examination of the gear of the cars. Four hydraulic elevators are provided for supplying and removing the cells to and from the cars, and each has eight shelves capable of storing sufficient cells for 16 cars. In addition to this there are shelves in the accumulator room which will carry sufficient cells for two further cars. The charging of these can be carried on simultaneously with the batteries on the elevator cages. The elevator cages are open, so that the cells are always under control and examination. A chamber underneath the elevators enables them to fall below the road level, and allows for examination of the hydraulic machinery.

The engines and boilers and machinery to generate the electric force are all laid in duplicate, each engine is guaranteed to deliver 100 horse-power from the fly-wheel. The two boilers are of steel, of the "Economic" safety multitubular type, 12ft. 6in. long and 7ft. 6in. diameter, and the flues, 28in. in diameter, are fitted with two Galloway tubes and with Paxman's expansion joint and other best-known appliances for heat economising and smoke consumption. Provision is made for feeding the boilers either by injectors or by steam pumps either direct or through a "Green's economiser." The boilers are built to work at 120lb. on the square inch. During the excavations at the depot the engineers came upon a fairly constant water supply, which, together with the rain water, will be carried first into an underground tank in which the roof and surface drainage runs, and subsequently pumped to a large tank on the top of a tower 30ft high. It will then pass through a "Jewell" filter, and be used for feeding the boilers and washing the cars. Sand is used as the filtering material, together with a coagulated form of soda ash. A pressure of 3lb. per square inch will pass the water through the filter. The engines are of the "Receiver" type, non-condensing, with high and low pressure cylinders side by side, the former 12½in. diameter, and the latter 20in., and the length of stroke 24in. Paxman's automatic expansion gear is fitted. The fly-wheels are 8ft. 6in. diameter, and 17in. wide, and will make about 100 revolutions per minute. The leather link belting to drive the dynamos is carried in a belt-race lined with white glazed bricks, and this and the engines are enclosed by brass railings in cast-iron standards.

The two dynamos are in the engine room. They are of the "Elwell-Parker continuous-current" type, shunt-wound, with a capacity of 100 volts, 500 amperes, at an approximate speed of 540 revolutions per minute. Each dynamo will thus supply accumulator cells for twelve cars, in addition to the lighting of the depot, and power for the 9 horse-power motor in the machine-tool shop. Slides are provided for tightening the belts. The brushes, which are so arranged as to bear lightly on the accumulator, are carried in movable rockers. Two spare armatures to fit either dynamo are provided. Resistances are arranged for maintaining constant volts at the dynamos. The batteries are of Elwell-Parker make, with ten negatives and nine positives, 8½in. by 6½in., with vulcanite separators. The cells, which are in vulcanite cases, are firmly secured in teak trays. 96 of these cells are required for each car, giving a total force of about 192 volts, and yielding a current of about 35 amperes. From the construction of the cage-elevators any number of cells can be charged at one time, and the operation of connection is automatic. Portable voltmeters and hydrometers are used during charging. Strips of copper run along the guides of the lifts, the current is taken off by spring contacts. These strips are connected through fuses to a switchboard. There are five of these boards, each having ammeters, fuses, resistances, and switches for the eight shelves of the hydraulic lift. The cables from the five boards are led along the tie rods of the roof to a main switchboard provided with Cardew voltmeters, ammeters of a capacity of 600 amperes, and main fuses and switches. The whole of the buildings are lighted by 16 candle-power incandescent lamps, with two 200 candle-power lamps over the entrance to the charging station.

The hydraulic pumps provide a supply of water at a pressure of 700lb. to the square inch by accumulators to the lifts. The car sheds, charging sheds, boiler and engine house are paved with cement concrete, and the mechanics' shop and battery room with wood block flooring. The boiler chimney is 110ft. high, with a diameter of 4ft. at the cap, and is lined with 4½in. fire-brick. A lightning conductor runs down the shaft into the underground tank already mentioned.

The electrical and mechanical fittings have been supplied by the Electric Construction Corporation, of Wolverhampton (late Elwell-Parker's), and are on the "Julien" principle. The cars are 26ft. 6in. long, with platforms at either end, and 6ft. 3in. wide, and have a carrying capacity for 24 inside and 26 outside passengers. The body of the car is carried on two bogie trucks of T iron, strengthened by King trusses, and about 15ft. between centres. They resemble the cable cars of the same Company. The outside seats are reversible garden chairs, and inside are of the usual longitudinal kind, with a centre passage. The woodwork below the plate-glass windows is polished teak, in panels which slide vertically, so as to give access to the trays and cells underneath the seats. There are six trays on each side of the car, and each tray holds eight cells, making 96 in all, and the teak trays are carried in three runners on the car floor. When the trays are pushed into the cars they are secured and automatically connected-up by V-shaped copper contact blocks, and the conductors from cells (in four groups of 24 each) brought up to switch used by the driver. By this arrangement the four groups of cells may be connected with the motor in six different ways, and the necessity of resistance coils in the circuit is obviated and uniformity of discharge is secured.

The first position of the switch leaves all the groups disconnected; the second puts them in parallel, but not in circuit with the motor; the third puts them on to the motor; the fourth puts the groups half in series and half in parallel; the fifth cuts out one group, leaving three in series; and the sixth position couples all in series. The object of the second position is to allow an equilibrium to be made by the batteries in case one group has run down more than the others. The other positions obviously give one-quarter, one-half, three-quarters, or the full volts. The arrangement is covered by one of the Julien patents. It will be noted that no resistances are used on the car.

The motors are of the Elwell-Parker type, double limb, series wound, and run with 140 revolutions; but a velocity of 700 revolutions is required to maintain a speed of eight miles an hour. One motor is supplied to each car and carried on one of the bogie trucks by means of an aluminium brass frame, three points of which are rigidly fixed on one axle of the bogie, and the fourth rests on the second axle through a strong helical spring that makes it independent of any change of load or oscillation of the car. A helical pinion on the motor shaft gears with two intermediate wheels on two countershafts, which drive the axles of the bogie by other helical-geared wheels, the whole ratio being about 6¼ to 1. The driver's switch is placed underneath the steps of the platform in a teak matchboard casing, and quite out of the way of the passengers. The inside seats of the car are hinged so as to afford access to the accumulators, and the portion of the floor over the motor is also movable. The cars will be lighted by a 16 candle power incandescent lamp at each end, and the brake provided is of great power, gripping all the wheels at once.

The Public Works Committee has not given its consent to the running of electric cars, but the Company has been informed that no objection need be anticipated. All the cars have been delivered, and as soon as the necessary permission is obtained the service will be commenced.

The permanent way outside the city and also the buildings at the depôt were designed by Messrs. E. Pritchard and Joseph Kincaid, engineers to the Company; and the whole of the works have been executed under the superintendence of Mr. A. W. Pritchard for the engineers.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 11, 1890.

Steam Supply.—The New York Steam Heating Company, which has been responsible for much damage in the lower part of the city, and which has seriously interfered with the electric subways in the locality, seems at last to have overtaxed public patience. It has been ordered to cut off steam from its mains

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throughout the larger part of Lower Broadway; and legal steps will be taken to see that the order is obeyed. The pipes in their present situations are condemned as a public nuisance.

Physiological Effects of Current.—Dr. Edward Tatum, whose experiments on the physiological cause of death by electricity have attracted some attention, is likely to continue further investigations on the subject. His work down to the present time has done much to clear up the subject he has taken in hand, and is especially interesting as it calls special attention to the differences which exist between continuous and alternating currents in their effects upon a living organism. He has made it very evident that the continuous current does not kill through any action upon the nervous system, but rather through direct effect upon the substance of the heart. The alternating current, on the other hand, does its work in large measure through action upon the nerves and inhibitory mechanism of the heart, thus producing more fatal results in proportion to its actual current strength.

Traction Experiments.—A vigorous effort has been made to depreciate electrical traction by the publication of some experiments tried on the New York elevated roads more than a year ago. The Paper shows a lamentable degree of ignorance on the part of the author of what has been done even in electric street-car work. The experiments showed an efficiency from engine to car wheel of only 15 per cent., whereas it is notorious that 50 per cent. can be reached in street-car practice on a line of similar length. The cause of this extraordinary result may be found purely in the fact that the engine-furnishing power was of about 500 horse-power, while the actual effort required to draw the train at the speeds employed was less than 30 horse-power. To draw any conclusions as to the economy of electrical traction from an efficiency computed with such data shows dense ignorance of the ordinary principles of mechanics. The speed of the train with which these experiments were made was so slow, too, that the motors must have been working at an efficiency far below the normal, although the details are not given in the Paper read by Mr. Moss. The constant loss from friction of engine, dynamos, and open-circuit losses on this line amount to more than 40 horse-power, which renders the deductions made from the experiments absurd, if anything more were necessary than the facts regarding the size of engine which I have just given.

The Duncan Motor.—Some experiments recently tried with a motor invented by Dr. Louis Duncan, of Johns Hopkins University, have given results so remarkable as to attract considerable attention. The motor is a multipolar machine of 15 horse-power nominal, and an output of 10 horse-power was obtained from it at an electrical efficiency of 92 per cent., and a speed of 90 revolutions per minute; this in spite of the fact that the armature was of cast iron. This very remarkable result is obtained by employing a large number of poles, and a commutator with rather complicated cross connections. Unless further experience should show results remarkably below those accepted by the experimental machine, it would seem that we have here a solution of the difficulty heretofore met in electric traction—that is to say, the necessity of high armature speeds and geared motors. Dr. Duncan is certainly to be congratulated on his remarkable success with the new machine.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *July* 12, 1890.

Sweden's telegraphic correspondence for last year amounted to 1,768,892 messages, of which 60,140 messages were for service and meteorological telegrams, and for these no fees were paid. There were also transmitted about a million "repetition" telegrams. The chargeable telegrams consisted of 939,624 inland and 769,128 foreign, and 182,569 messages passed through the country, mostly between Russia on the one and England on the other side. Of the telegrams 13,990 were State messages, and 18,917 express telegrams. Compared with the chargeable telegrams of 1888, there is an increase of about 25 per cent. Of these the home traffic represents an increase of 52·2 per cent. The receipts from the telegrams amount to 1,393,732kr., or 13,094kr. less than 1888, a decrease equal to 0·9 per cent. The decrease is, of course, caused by the reduction in the charge for inland telegrams. Home telegrams have yielded about 0·73 öre (about 10d.) per message, and the international telegrams 0·92 öre (a trifle above 1s.) per message. The Swedish share of direct foreign telegrams was, however, 1kr. 14 öre (about 1s. 3d.), and on the transit telegrams only 0·24kr. (or about 3d.). Last year the average pay for home telegrams was 1kr. 13 öre (1s. 3d.), but the charge was reduced to half at the beginning of 1889.

Although, of course, large quanti ties of electric fittings are imported into Sweden, yet the manufacture within the country is continuously extending. As a recent example, may be mentioned the erection in Gothenburg of a manufactory for incandescent lamps. At these works will be adopted a new proces for repairing or restoring incandescent lamps, which is said to have given very good results.

The installation for electric street lighting of Sundsvall, Sweden, has been secured by the firm of Eriksens, Mekaniska, Balog, Stockholm, as agents for Siemens and Halske, Berlin. The contract comprises three dynamos, accumulator, and 50 arc lamps. The cost is about 82,000kr., and the works will be completed by Christmas.

The electric lighting of the Royal Castle at Stockholm has been gradually extended, both in the interior and outside the huge building. Nine ampere arc lamps will be placed outside the southern and western entrance gates of the Castle.

Some of the apartments of the Castle of Fredensborg have also been fitted with electric light lately, which is now making steady progress in many parts of Scandinavia, where there has hitherto been a considerable opposition against it, especially in Denmark.

The Stockholm Bell Telephone Company held its annual meeting the other day, and although it can of course not vie with the Stockholm General Telephone Company, it shows fair progress. The subscribers numbered at the end of last year 1,751, of which 1,324 were the Company's own subscribers, and 327 subscribers in other societies. The gross profits amounted to 140,446kr., working expenses were 85,815kr., and interest 6,240kr. The net profits were applied to various writings off, and no dividend was declared.

The State telegraphs in Norway show a considerable increase in receipts, and the reduction in charge for telegrams, which was adopted some three years ago, has brought about a material increase in the takings. In the financial year 1887-88, previous to the change, the takings amounted to 868,000kr., but rose in the next financial year, after the introduction of the reduced charge, to 1,013,000kr. In the last financial year there was a further rise, and for the pending year they have been estimated at 1,120,800kr. During the pending year a sum of 167,800kr. will be applied to new State telegraph and telephone installations. Continuation of the Vodsö-Toneneto telegraph will require 60,000kr.; a third wire on the Vaterfjord-Lodingen line 23,500kr.; line from Ulne to Odde 26,000kr.; line from Flekkefjoord to Hiterö 10,000kr.; line from Ölen to Sand, 25,000kr.; telephone to Grindaheim in Volders, and extension of the Töusaasen-Fageruös Telephone 15,300kr., &c. Altogether, a number of out-of-the-way places are gradually being brought into telephonic communication with the world at large, either by State telephones or private enterprise. During the financial year 1888-89 the profits on the Norwegian State telegraphs have been 163,000kr. more, and expenses 6,000kr. less than calculated, a state of affairs which can but be called satisfactory.

Delegates from the Aalborg, Aarlens, Fredericia, Grenaa, Habro, Holstebro, Sljörring, Randers, Ringkjöbing, Silkeborg, Skive, Veile, and Viborg telephone companies in Jutland held a meeting last week. A committee was appointed for the purpose of framing rules for a joint management of all the telephone companies in Jutland.

CORRESPONDENCE.

FIRE OFFICE RULES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I venture to trespass on your valuable space in reference to a matter which is engaging a considerable amount of attention among electrical contractors at the present time, viz., fire office rules.

Formerly most contractors carried out their work as nearly as possible in accordance with the Phœnix rules, but now nearly every fire office has a special set of rules for electric lighting on its own account. This was, of course, to be expected, as competition among insurance offices is as keen as in any other business.

What is the electrical contractor to do? In an important installation the building and contents are often insured in three

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or four leading offices, all of whom ask if the work has been carried out in accordance with their particular rules; and how can this possibly be done when the rules vary in important respects?

It seems to me that the sole remedy is for electrical contractors to work carefully in accordance with the rules laid down by the Institution of Electrical Engineers. If these rules are considered insufficient in any particular respects contractors will soon hear of it, and where there is any consensus of opinion a report should be made to the Institution, and a periodical revision of the rules undertaken by a committee.

This, I believe, would do away with the present hopeless condition of affairs, when a surveyor from one leading office expresses great satisfaction with work one day; and the next day a surveyor from another equally important office swoops down and harasses the contractor by demanding alterations, which can best be described by F A D in capitals.—Yours, &c.,

JOHN B. VERITY.

31, King-street, Covent-garden, July 17, 1890.

"PROVING" OHM'S LAW.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question which is raised by the communication which Prof. Lodge is circulating in consequence of the memoranda of Profs. Fitzgerald and Chrystal seems to need some care in handling, if it is not to increase the obscurity of the subject. If resistance is defined as the ratio of the electromotive force to the current which it produces, then the proposition that the electromotive force, divided by the resistance, gives (numerically) the current, is one which no more admits of discussion, nor needs experimental verification, than do the most elementary propositions of algebra. The experiments suggested by Maxwell, and tried by Prof. Chrystal, and those carried out by Prof. Fitzgerald, important though they are, cannot possibly be wanted to verify or prove Ohm's law. What they do go to verify or prove is, not whether the mathematical relation that bears the name of Ohm is true, but whether that property of an electric conductor which is called its "resistance" is, or is not, a constant. Now, it is common knowledge that the resistance is the function of at least one variable—the temperature; and it is quite a legitimate topic for inquiry, as Maxwell suggested, whether it is or is not also a function of another variable, namely, the density of the current passing through it. But why draw the line at these two variables? May it not equally be a function of such variables as the magnetic field in which the conductor is placed, the intensity of the illumination of its surface, the intensity of sound falling upon it, the intensity of the circumambient medium, the slope of temperature between its various parts, and the like? If it were found that the resistance of a conductor varied with any of these, surely one would not say that Ohm's law was false. One would simply say that the resistance was variable, and that if in Ohm's law one wrote the true value of the resistance corresponding to the circumstances, Ohm's law must then truly express the facts.

Now, whether this is granted or not, I invite the attention of the disputants in this matter to the very simple fact that for certain conductors, notably for iron and for bismuth, the resistance which they offer to currents of small density is assuredly not the same as the resistance which they offer to currents of large density, even if the temperature is artificially maintained equal in the two cases. It is known that these two metals—amongst others—when placed in a magnetic field change their resistance. The fact was first discovered by myself and Mr. C. C. Starling in the case of the metal tin; it was almost immediately afterwards independently detected by Righi; it has been measured by him, and also by Tomlinson; it has been made by Leduc and others the basis of a method of measuring the intensity of magnetic fields. Of the fact there can be no doubt. Neither can there be any doubt that when a wire of iron, or of bismuth or any other metal carries a current, a magnetic field is created circularly around the wire, partly outside it, also partly inside it. Also the intensity of this circular magnetic field within the metal depends upon the strength of the current. Hence it is *absolutely certain* that the resistance which an iron wire or a bismuth wire offers to a large currents, is different from the resistance which it offers to a small current.

But shall we, because we find that resistance is a function of another variable besides temperature, forthwith pronounce Ohm's law false? Surely the more rational mode of procedure is simply to acknowledge that resistance is not a constant.—I am, yours, &c.,

SILVANUS P. THOMPSON.

SHALL THE GOVERNMENT BUY UP THE TELEPHONE?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In speaking of the telephonic business you appear to me to have fallen into a contradiction and a misconception of the situation that, acted upon, will have very disastrous results upon electrical and all other progress. You first point out that telephony is rather dearer in England than in some other countries, because the Government lay a tax of 10 per cent. upon the companies who supply this mode of communication; and then, further on, you say that 10 per cent. is a very moderate charge to be allowed to earn 6 per cent. It cannot be to the benefit of anyone that telephoning should be more expensive than it naturally would be. If you approve of this 10 per cent. charged, you must approve of its results—dear telephoning. To bring it home to you, would you approve of reimposing the paper duty in the interest of the public, or in fairness to yourselves? Socialistic ideas seem so to have distorted our vision that the sound old Manchester school of political economy is discarded, as if its teaching had been exploded, which it has not. And then you regret that the Government, with its surplus, is in such a state of impecuniosity that it cannot see its way to buy up the telephone. Can it possibly be to the benefit of any one that an agency, which has shown its incapacity to compete with private enterprise even when handicapped with a 10 per cent. impost, should be entrusted with the conduct of this new enterprise? Let us just look back upon the action of Government upon the whole of the electrical field of enterprise, and see if it justifies the blind faith that we place in it. To begin with, Mr. Chamberlain snuffed out the electric light in England for ten years with his Electric Light Bill, a valuable service for which it is truly astonishing that he did not receive a peerage. Then, when we come to electrical traction, Mr. Reckenzaun declares, and all other authorities confirm what he says, that the greatest obstacle to its introduction and development is the Public Authorities. The story of the electric telegraph is a similar one, but is too long to go into. To return to the telephone companies, is it not quite clear that if they had not been hampered with this 10 per cent. tax they would have been in a much better position to develope and extend their business by lower rates of charge at which they would have had greater profits from the larger volume of business? Then, again, you praise the management of the directors of the telephone; and here lies the secret benefit of private enterprise, that it trains and educates an able body of men, and brings out their best qualities and abilities in a way that officialism does the very opposite of. Mr. Raikes, whose own performances are anything but satisfactory, you tell us has let the telephone companies know what he intends to do with them, which means that after letting them grow a bit, and showing him how to do the thing, he will rake them up and plant his officials in their place. The school of private enterprise was that in which Englishmen learned to be great and able; but although it served us splendidly, we are throwing it to one side in favour of the wretched one of officialism, that is incapable of progress, costly and inefficient, and offers a premium to sluggishness, apathy, incapacity in high places, and hopeless drudgery in the lower ones. It is truly sad to see a people who once believed in freedom turning back to bondage and hankering after the flesh-pots of officialism and Government bribes. Shall we ask the Government to buy us out altogether, that we may sit and vegetate; or to leave us free that we may live our own lives and fight our own battles?—that is the question.—Yours, &c.,

42, Richmond-terrace, South Lambeth, London, S.W., July 18, 1890. H. W. FAWCUS.

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CHARLES MORRISON AND THE ELECTRIC TELEGRAPH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In one of your leaderettes last week (page 271), with regard to a reference of mine to Charles Morrison, you say that it seems doubtful "whether a telegraph has ever been constructed on this principle." Now, whatever may be thought of the value of Morrison's work, a question which I do not wish to raise here, I think there is very little doubt that he actually made the experiments described in the *Scots Magazine* for February 1st, 1753. It is true that his letter is vague on this point, but there was contemporary evidence that he did transmit messages short distances along wires by means of electricity. Indeed, there are good grounds for believing that his experiments made it necessary for him to leave the country, as his superstitious neighbours thought he was in league with the devil, and acted accordingly. He therefore went to Virginia, and efforts have been and are being made to trace his subsequent life there, but hitherto without success.—Yours, &c.,

R. MULLINEUX WALMSLEY.

Heriot-Watt College, 23rd July, 1890.

LEGAL INTELLIGENCE.

Stanley and Davies v. Milner and Co.

In the Manchester Civil Court last week, the case of Stanley and Davies v. Milner and Co. was before Mr. Justice Vaughan Williams and a common jury.

The plaintiffs, who are engaged in business as electrical engineers, sought to recover from the defendants, who are bleachers and finishers at Pendlebury, £136 for goods sold and work done. An installation consisting of 46 lamps was placed in the works, and the illumination was so complete that Mr. Milner expressed himself satisfied with it. Complaints were made later by the defendants that the installation was working improperly. The plaintiffs went and found that a man was in charge of the installation who knew nothing about it, and that the defendants' workpeople did not take due care of the machinery. The installation only consisted of 46 lamps, and of these not more than eight had been the subject of complaint. The defendants had pleaded that the whole installation was useless to them. Some of the wires also became corroded owing to the aciduous vapours that floated about the works,

Counsel for the defence submitted that the contract with the plaintiffs was for the wire to be of the best insulation, and of the highest conductivity of copper. The work was to be done in the best possible manner, and to be fit for a bleachworks. It was admitted in the plaintiffs' case that the wire inserted was not "of the best insulation and the highest conductivity of copper." That was a material point, because the fact that corrosion ensued showed that the material could not have been of the highest kind, or that it was fitted in the best possible manner.

The JUDGE said that on the contract as it stood it was extremely doubtful whether the sellers of the machinery contracted to supply machinery suitable with reference to the peculiarities of bleachworks. The whole question of the case was whether the plaintiffs were bound to supply machinery which should afford protection against these vapours.

Mr. FAWCUS, manager for the Edison and Swan Company, considered the wire not only unfit for bleach-works, but altogether unsuitable for electric lighting. He should not like to say that the machinery was useless, or to put any value upon it.

The JUDGE: What would be the most prudent thing for a man to do with that installation in your opinion? Would you take it out and get a new one, or alter it so as to get rid of the present defects?—I should certainly take it out and get a new one. The present dynamo might be used again, but new wiring is absolutely essential.

Mr. FLEMING having addressed the jury on the evidence, the Judge summed up.

After a brief absence the jury returned a verdict for the plaintiffs for the amount claimed; and judgment was entered accordingly.

Sharp and Kent v. Dane.

This was an action brought at Westminster County Court on Thursday last week by a firm of electrical engineers, to recover damages against the defendant for wrongfully absenting himself from his employment. The plaintiffs' case was that the defendant left work on June 26th last, about twelve o'clock in the day, without giving any reason, except that he declined to work under a foreman named Brittain.

The defendant was called, and said he had been very badly treated by the plaintiff firm. It was true he refused to work under a foreman named Brittain.

His HONOUR said he failed to see that the plaintiffs had sustained any damage by the defendant's conduct; but he would give them a verdict for the nominal sum of one shilling, but no costs would be allowed.

THE NORTHERN ELECTRIC WIRE AND CABLE COMPANY.—Last week Mr. Justice Kay heard an application on behalf of Mr. Edward William Hall of Park House, Bradford, Yorkshire, to correct the register of the Northern Electric Wire and Cable Manufacturing Company (Limited), by removing his name from the list as holder of 160 shares. This was an application under Section 35 of the Act of 1862, and the contention of the plaintiff was that he had not entered into a contract to take the shares in the Company; and that, in fact, at the time the allotment of shares was alleged to have taken place he had not applied for the shares, although he had a few weeks previously received from Blakey, Emmott, and Co., the vendors, a copy of the prospectus of the defendant company. After a lengthy legal argument, his lordship said it seemed to him that in the present case there was no binding contract. He went in detail through the facts of the case, and concluded by saying that the whole of the proceedings had been so grossly irregular that he must order the applicant's name to be removed from the register, and the £80 paid on the shares by the plaintiff to be repaid, with interest.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

TENDERS WANTED.—It will be seen by our advertisement columns that the Melton Mowbray Local Board invite tenders for lighting, during the ensuing year, the streets within their district, according to the specification, which can be seen at the office of their Surveyor. The tenders have to be delivered to Mr. Richard Barker, Clerk to the Board, not later than 3 o'clock on the 12th August next.

——— The Dirección General de Correo y Telégrafos, Madrid, will receive tenders up to August 11, 1890, for the installation and working of a telephone service in Las Palmas, Canary Islands.

BUSINESS FOR SALE.—Our advertisement columns contain notice of the sale, by private contract, of the valuable goodwill, with immediate possession, of a well-known manufacturing and retail business in mathematical and philosophical instruments, &c., in one of the best positions in Birmingham, which has been established over 38 years. Further particulars may be obtained of Mr. Arthur J. Pass, auctioneer and valuer, 50, New-street, Birmingham.

PLANT FOR SALE.—Our readers will find in another column particulars of a complete plant for 4,000 lamps, which is for sale, ready for fixing, comprising alternating-current dynamos and transformers (by Goolden and Co.), ammeters and exciters (by Goolden and Co.), and two 30 horse-power engines and boilers. Further information is to be obtained from the Secretary, Westminster Electric Supply Corporation (Limited), 4, Victoria-Mansions, Victoria-street, S.W.

PERSONAL.—Mr. Mark Bevan, who was for several years superintendent at Rio de Janeiro of the Western and Brazilian Telegraph Company, and for 4½ years in the service of Messrs. Siemens Bros., has established himself at West Bute-street, Cardiff, as an electrical engineer and contractor.

MESSRS. SIEMENS AND HALSKE.—Messrs. Siemens and Halske have opened a new factory in Apostelgasse and Hamburgergasse, Vienna, where electric cables of all descriptions will be manufactured.

ELECTRICAL INSTRUMENTS.—The contracts for the supply of electrical instruments to the London and North-Western Railway Company and for the Caledonian Railway Company for the ensuing year have been secured by Woodhouse and Rawson United (Limited).

THE ELECTRIC FITTINGS AT THE NEW HOTEL METROPOLE, BRIGHTON.—This splendid hotel was opened on Saturday last, and the electric light installation was much admired. A special feature of the installation is the "electric sunlights." In the principal suite of three large public dining-rooms these "electric sunlights" have been fixed within a very few feet of the ceiling of each room. They comprise a large handsome deep inverted embossed brass dish, within which are a number of glow lamps, the whole being surrounded by a fringe of cut-glass prisms, giving a most brilliant effect. These "sunlights" were manufactured by Messrs. Benham and Froud, of Chandos-street, in accordance with the ideas of the proprietors of the hotel. For the bed-rooms, portable table pillars, of four types, having opal shades covered with silk and lace, of tint to harmonize with the decorations, have been selected; and for the private sitting-rooms and vestibules, electroliers in brass, richly chased and burnished, with three to ten lights each in tinted and cut shades. Messrs. Benham and Froud are certainly to be congratulated on the effect obtained.

MESSRS. BEREND AND CO.—Messrs. Berend and Co. of 61, Fore-street, have sent us a book of pole-testing paper. Although not a novelty, this paper is very useful, and a few pieces may be kept in a purse or pocket-book. When moistened by the tongue, and touched by two wires, a red spot appears at the negative pole.

THE CONSOLIDATED ELECTRIC STORAGE COMPANY OF THE UNITED STATES.—This Company announce that they are manufacturing the Julien storage battery, and are exclusive licensees for the United States of the storage battery patents of Charles F. Brush.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.

June 21, 1890.

9,668. J. P. HEBENDAHL, G. MILLER and E. F. WARNER. Improvements in elevating and lowering electric lights.

June 24, 1890.

9,780. W. J. SMITH and J. W. FOX. London. Improvements in electric railway signals.

9,786. L. HÉNDLÉ and E. SCHUBERTH. Forest Gate. An improvement on electric incandescent lighting, called "the non-consuming glow-light filament."

June 25, 1890.

9,840. R. DRYSDALE and H. B. LOWE. Birmingham. Improvements in astatic galvanometers.

June 26, 1890.

9,898. T. M. WATSON and A. H. WATSON. London. Improvements in connection with electric ships, binnacle, side, and indicator lamps.

9,904. W. H. CLARKE. London. Improvements in armatures for electrical apparatus, such as dynamos, motors, and transformers.

9,917. A. M. CLARK. London. An improved electrical-circuit closer. (R. and G. Drummond, South Africa.)

9,937. S. W. TRACY and JAMES E. GRANNISS. London. Making lead pipe or covering insulated electrical conductors with lead sheaths.

June 27, 1890.

(!) . T. PARKER. London. Improvements in or connected with the manufacture of iron by electrolysis.

June 28, 1890.

10,038. A. WATT. Balham. Improvements in the electrolytic treatment of metals.

June 30, 1890.

10,064. T. G. MARSH and G. T. BARLOW. Lytham. Improvement in electric light fittings.

10,076. R. H. GOULD and S. GOTTSCHALK. London. Improved safety connections or couplings for electric conductors.

10,090. J. A. BRIGGS. London. Improvements in dynamo and electric motor machinery.

10,100. A. M. FLACK. London. Improvements in and relating to electrical indicators.

10,124. M. W. DEWEY. London. Improvements in electric heating apparatus.

July 1, 1890.

10,125. J. L. KIMBALL and H. C. WIRT. London. Improvements in electric cut-outs or apparatus for controlling the flow of current of electrical energy.

10,134. J. Y. JOHNSON. London. Improvements in covered or insulated electric cables or conductors, and a compound therefor (J. H. Cheever, United States).

10,137. R. H. WILLIAMS. Egham, Surrey. Obtaining motive power by a method and means or apparatus in connection with any mechanical or electrical motor or combination of both.

10,183. H. H. LAKE. London. Improvements in electrical cut-outs and fixtures connected therewith (S. Bergmann, United States).

10,187. W. P. THOMPSON. Liverpool. Improvements in or appertaining to self-exciting electric generators (W. Stanley, jun., and O. P. Shallenberger, United States).

July 2, 1890.

10,211. VINCENT FABRIS. London. Improvements in electric primary batteries.

10,229. A. GREEN. Hollinwood, near Oldham. Improved means for decomposing sewage water by oxidising zinc by electric current.

10,271. N. MITCHELL. London. An improvement relating to medico-electric batteries.

July 3, 1890.

10,276. H. J. ALLISON. London. Improvements in electric search lights and in mechanism for feeding the carbons.

10,305. W. H. FASSETT. London. A combined electrical comb-curler and curling tongs for the hair (R. Scott, United States).

10,316. J. D. F. ANDREWS. London. Improvements in joints for armoured electric conductors.

July 4, 1890.

10,342. G. M. COOMER. Bristol. Cleaning knives. Intended to be called "Coomer's electric knife cleaner."

July 5, 1890.

10,406. J. PERRY. London. Improvements in electrical measuring instruments.

10,421. J. BRADFORD. London. An improved method or means for the prevention of accidents from the over-heating of electrical wires.

July 7, 1890.

10,508. J. HOPKINSON. London. Improvements in electrical railways and tramways.

10,515. A. J. JARMAN. London. An improved connector for the electrodes and cells of primary and secondary electrical batteries.

SPECIFICATIONS PUBLISHED.

Second Editions.—1881.

3,122. LANE-FOX. Electric bridges for lamps. (Price 4d.)

1882.

1,079. CROOKES. Incandescent electric lamps. (Price 6d.)

11,032. OULTON and EDMONDSON. Electric meters. (Price 8d.)

11,419. SIEMENS BROS. and CO., LIMITED (Siemens and Halske). Electric meters. (Price 8d.)

11,596. BARLOW. Conduits. (Price 8d.)

13,149. PARKER. Obtaining reciprocating motion from electric currents. (Price 6d.)

13,459. DOWNING (Weydetors). Electric accumulators. (Price 1s. 3d.)

Amended Specifications.—1885.

4,671. FITZGERALD. Voltaic batteries. (Price 8d.)

Reprints (with alterations).—1888.

18,494. ROBERTS and BREVOORT. Galvanic batteries, &c. (Price 8d.)

1889.

6,458. HOHO. Electric currents. (Price 1s. 1d.)

10,057. DUGGAN. Railroad switches. (Price 8d.)

10,342. MEWBURN (La Société Anonyme pour le Travail Electrique des Métaux). Secondary batteries. (Price 8d.)

11,528. BEYER and HAGEN. Electric accumulators. (Price 8d.)

11,832. DOLBY. Electrical conductors. (Price 6d.)

12,901. CROMPTON. Electric accumulators. (Price 6d.)

13,322. MERCADIER. Transmitting electric signals. (Price 8d.)

1890.

1,347. COAD. Primary batteries. (Price 4d.)

1,644. LINEFF. Electric traction. (Price 1s. 1d.)

2,302. WEYMERSCH and MCKENZIE. Electric batteries, (Price 8d.)

3,924. LAKE (Crosby Electric Company). Electric batteries. (Price 6d.)

3,984. DUVAL and NELSON. Electric, &c., lights. (Price 6d.)

5,728. LAKE (Foote). Dynamo, &c., machines. (Price 8d.)

5,782. HIORTH. Electric lamp. (Price 6d.)

6,176. BARKER (Woodward). Secondary batteries. (Price 8d.)

6,236. JARMAN. Storage battery. (Price 8d.)

6,492. DEWEY. Electric railways. (Price 8d.)

6,493. DEWEY. Electric refrigeration. (Price 8d.)

6,568. LAKE (Garver). Electrical measuring instruments. (Price 8d.)

6,569. LAKE (Weston). Electrical measuring instruments. (Price 8d.)

6,581. LAKE (La Société L'Incandescence électrique). Incandescence electric lamps. (Price 6d.)

6,956. BOYNTON. Electric, &c., railways. (Price 11d.)

7,209. SAUNDERSON. Electric arc lighting. (Price 8d.)

7,425. CONLY. Electric currents. (Price 8d.)

7,444. MILLION and BONY. Galvanic batteries. (Price 6d.)

Second Editions.

6,199. HANDFORD (Edison). Distribution of electrical energy. (Price 8d)

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The thirty-sixth half-yearly ordinary general meeting was held on Thurs day, July 17, 1890, at Winchester House, Old Broad-street, London; Sir John Pender, K.C.M.G., in the chair.

The SECRETARY (Mr. George Draper) read the notice convening the meeting, and the minutes of the last general meeting; and the report having been, at the request of the meeting, taken as read,

Mr. CLARKSON (a shareholder) said: In order that there may be no mistake, I wish to inform the Chairman that at the proper time I shall have something to say, and I therefore ask him not to pass the resolution without giving me the opportunity of speaking.

The CHAIRMAN: Now, gentlemen, I will, as has been usual on these occasions, make some remarks on the report and give you some further information as to the working of the system during the past six months. Our revenue for the half-year ending March, 1890, amounted to £424,023 as against in the corresponding half-year of 1889 (which owing to the activity in South Africa was an exceptionally good one) £435,932, showing a decrease of £11,909. But the balance brought forward from the September half-year accounts was £61,151 as against £36,616 in the corresponding period of 1889, being an increase of £24,535. We have, therefore, an increased available amount to deal with of £12.626. It will be observed that our dividend on Direct Spanish shares is £246 more than

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in the corresponding period ; and I have much satisfaction in calling attention to the dividend which we have received from the African Direct Company, viz., £1,500, being at the rate of 4 per cent. per annum for the half year to 31st Dec. last. The African Direct Company was formed to carry out an important work, viz., the establishment of telegraphic communication with the British Colonies on the West Coast of Africa ; but the local traffic of the line was very small, and even with the subsidy received from the British Government the Company was unable to meet its working charges. Now, however, that it has a share in the South African through traffic, the African Direct Company is showing a small profit, and we may hope that in future our investment in this Company will be a fairly remunerative one. The total working expenses for the half-year to March, 1890, amounted to £98,477, as against £92,448, being an increase of £6,029, the details of which are as follows:—General expenses in London £8,726, against £7 988 or an increase of £738. This is in salaries, office expenses, rent, stationery, and printing, &c., consequent upon the continued development and expansion of the Company necessitating additional staff and accommodation. Working expenses at stations amounted to £72,677, against £68,545, or an increase of £4,132, the principal item of which is in the salaries of our station staff at home and abroad, which was fully explained and approved at the last general meeting. The number of staff at stations in 1890 was 637, against in 1889 582, or an increase of 45. On the other hand, several of the items under Abstract "B" show a decrease, namely—repairs and renewal of furniture at stations £1,109, repairs to stations £423. Depreciation of cable stock is also less by £654. Repairs to cables amounted to £47,520, against £48,665, or a decrease of £1,145. Full details of the expenses of the ships, &c., and cables used for repairs, will be found on reference to Abstract "C" in the accounts.

You will find as a charge against reserve fund a sum of £5,397, for loss, owing to a robbery at Athens from our banker. He received the money too late to remit it, and between that time and the next morning it was abstracted. We have not yet been able to recover the money, but we are on the track still. Whether our efforts will ever be successful it is very difficult to say. I may mention that our banker there was agent of the Company in one way and another for 18 years. He was a man who had a very high character, and we had known him personally. Unfortunately, when this robbery took place, he was on a sick bed, and he has since died.

After providing for all expenses and interest charges against revenue, we are able to recommend a final dividend at the rate of 5 per cent. per annum, and a bonus for the year of 1½ per cent., making a total distribution of 6½ per cent. on the ordinary shares. We carry £125,000 to the general reserve fund, which now amounts to £607,000.

Now, gentlemen, when I last addressed you, I referred to the West Coast of African system as being fully completed, and I said I believed we should have important results. I am glad to confirm that opinion to-day. The African Direct Company is paying 4 per cent., and I hope in another year you will see an increase on that dividend. The West African Company are paying a dividend of 5 per cent., and I also expect to see an increase in the case of that Company if the state of things which has hitherto existed in Africa continues. Altogether we are now in a position to meet all the requirements in the course of the development of that dark territory which has been so much before the world in the last few years. We are, as I have said, I think, on a previous occasion, ahead—we are prepared to do our part in connecting that new world with the old, and I hope it will be not only in the interests of civilisation that we shall do so, but materially in the interests of our shareholders.

I also said at our last meeting that we had had some little trouble in Egypt, and that these settled I looked forward to a better state of things in that country. I mentioned at the same time that I was about to proceed to Egypt, which I did ; and the result of that visit, I may safely say, has been that we have settled our affairs with Egypt in such a satisfactory way that it will very materially benefit the Company, and at the same time benefit Egypt also. I may add that our relations with Egypt are now of a most satisfactory kind, and are likely to be so for many years to come. I also referred to the Telegraph Conference which at that time was coming on. I said that at Berlin we had had to make considerable sacrifices. The Paris Conference took place two months ago, and you were there very ably represented. There was no point that was not fairly argued and discussed ; and I am bound to say that the treatment of us by the general body of the Conference, representing the different Governments of Europe, was upon the whole very fair and very satisfactory to the Company. I think I mentioned that we have no vote at these Conferences. All our influence has to be brought to bear by putting strong sterling facts before the different representatives, and as a rule those facts have been generally fairly accepted, and dealt with ; and I think I may say, without fear of contradiction, that the Company's relation with the existing Governments of Europe in telegraph matters never stood higher than at the present time. I think the Company is indebted to our staff for the way in which our affairs were conducted at the Conference. Every member of the staff there did his best, and I think the result has been that we have come out of that Conference more satisfactorily than we have come out of any previous Conference. For the next five years, at all events, we are free, and I hope the comparatively small reduction of tariffs which have been made will be speedily recouped. We have to compete in the Mediterranean with different land systems, but as regards the reduction which has been made, I have no hesitation in saying that, having watched the progress of telegraphy, before I meet you again—or, at all events, before another year passes—we shall have recouped ourselves for any reduction of tariffs by an increased number of messages.

I may also mention another point, which I think very important, because it is not always very easy to deal with Governments. Governments have a great deal of red tape in their system of conducting negotiations ; and in our telegraph system we have as little red tape as can be used, for it would destroy our system. We have to be prompt in everything we do as to any telegraph negotiations. I am pleased to say that our relations with India were very materially improved at the Conference. India was represented there by a man of considerable intelligence, who thoroughly understood the subject ; and there was a give-and-take between the Company and the Government which, I think, has been highly beneficial to both. We have had, as I have just mentioned, to submit to certain reductions to Spain, Portugal, and Gibraltar ; but I hope they will be met by a considerable increase of traffic.

I have received a letter from an honourable shareholder—and I always like to pay attention to any letter I receive—in which he compliments the Board on their general good management, but he also says, looking to the large sum we are carrying forward, he thought the bonus ought to have been larger to-day than we have decided to declare. But changes have taken place since I last had the pleasure of meeting you. We know that a reduction will be made, and that what we shall lose will not be recovered within a year through the changes that have taken place since I last met you, and more particularly with regard to the Australian tariffs. We are going to make a remarkable reduction there, or, rather, the Eastern Extension Company are going to reduce their rates ; and whatever they do on the one side, we have to support on the other, more or less. Therefore we are parties to the arrangement with the Eastern Extension Company whereby they are going to reduce the tariff to Australia from 9s. 4d. a word to 4s. ; but in reducing it to that point we shall have the guarantee of the Governments of those colonies that they will pay one-half of any loss that may be incurred by the reduction. You will therefore have a stock which is, at all events for a period, partly guaranteed by the Australian Governments, and this should add materially to the value of our holdings. This reduction in tariffs must necessarily lead to a very considerable extension of our system generally, and our Red Sea cables have been in operation for some considerable number of years now.

Sir JAMES ANDERSON : Twenty years.

The CHAIRMAN : Nearly twenty years ; and we feel that we shall not be doing our duty to you or to the telegraphing public if we did not prepare at once for the increased traffic that must arise out of this great reduction of the tariff to Australia. We have, therefore, without hesitation, decided to lay another cable in the Red Sea from Suez to Aden. That cable will cost us at least £250,000. Now, looking forward to maintaining the respectable dividends we are paying at present, we think it is better, as far as we possibly can, to pay for that cable—or mainly to pay for it—out of our reserve fund ; and we have therefore increased our reserve fund to-day, as you observe, by a very considerable sum, so as not to add to our capital in extending our system to meet the growing demands upon it. I hope you will approve of that policy. (Applause.) I think it adds more to the value of your property by dealing with the matter in that way than by increasing your capital and eventually reducing your dividend.

I think these are the different points I wish to draw your attention to ; and the various remarks I have made in my statement will, I think, satisfy you that we are in a sound and satisfactory position. The amount that we are carrying to reserve is a very large one, and I have a great deal of sympathy with the gentleman who wrote this letter. Still, I am quite sure, when he has received the explanation which I have now made to you, he will prefer a trifle less dividend, feeling that he has a stronger security. I shall now move the resolution, but before doing so if any gentleman in the hall desires to make any remarks on the report or on the observations which I have just made I shall be very pleased to listen to him.

Mr. CLARKSON, a shareholder, having addressed the meeting at some length,

The CHAIRMAN said : Gentlemen, you have heard a very remarkable jumble of ideas, a great deal of it ancient history, quite irrelevant, and showing perfect ignorance on the part of the speaker. I therefore, with your permission, pass it over without further remark (hear, hear).

No other shareholder rising to address the meeting, the CHAIRMAN put the following resolution, which was seconded by the Marquis of TWEEDDALE, and carried unanimously :—

"That the printed report and accounts of the Directors to 31st March, 1890, submitted to this meeting, be and the same are hereby received and adopted. That a dividend on the Preference shares of the Company to 30th June, 1890, at the rate of 6 per cent. per annum, be paid less income-tax : and that in accordance with the Directors' recommendation a dividend be and is now declared of 2s. 6d. per share, with a bonus of 3s. per share, both free of income-tax, on the ordinary shares of the Company, making, with previous payments by way of dividend on account, a total payment of 6½ per cent. on those shares for the year ended 31st March, 1890."

The CHAIRMAN : That is the only resolution I have to submit to you to-day, and I am very pleased to find that you have accepted it so unanimously.

Mr. JAMES GIBB : I trust that you will not regard it as an impertinent intrusion into relations more sacred than business relations if I express for myself, and I am quite sure for the body of shareholders here present, our very deep sympathy with you, Sir, in the loss you have sustained by the death of Lady Pender. We have met you here from time to time, and we cannot, I am quite sure, have had other feelings than those of the greatest respect for you, and we have felt extremely for you in the present very trying circumstances. I will, therefore, ask the meeting to pass a resolution which I shall propose, recording a vote of condolence with Sir John Pender and his family in their present great affliction. I should like also to express our obligation to Sir John Pender, Sir James Anderson, and the other gentlemen who so ably represented the Company at the late Conference and have so well guarded our interests.

Mr. JOHN NEWTON : I hope I may be permitted to second this resolution. I may claim to be in a position to appreciate the value of the Chairman's services to you, and for the way in which he has opposed those on this

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side of the table, of whom I used to be one of the most prominent. Still, by the action I took I think I have benefitted the Company. I think that the manly way that you have struggled for the interests of this Company at all the Conferences which have been held, have given us such confidence and sympathy that you will not think it inappropriate that we should express to you on this occasion our regret at the loss which you have sustained. Moreover, we see that, notwithstanding this overwhelming trouble, you are at your post on this occasion. I second the resolution.

Dr. WALLER: I am very glad to find that these gentlemen have expressed the sympathy which I feel, and which is felt no doubt by every one who is present. It is an occasion of deep sympathy with me at least, and I am sure I am not exceeded in this feeling by anyone present. I have had the honour and pleasure of knowing Sir John Pender for twenty years, and have received from him from time to time the greatest courtesy and kindness, and none of the shareholders can feel more deeply than I do the loss which he has sustained. I believe this feeling will be perfectly unanimous. There are some domestic matters in which sympathy is better expressed by silence; and, therefore, I will not say another word except that I believe I represent every individual here in expressing our deep condolence with Sir John Pender in his trial.

Mr. GIBB: The resolution is as follows:—

"*The shareholders of the Eastern Telegraph Company (Limited), desire to express their sincere sympathy with Sir John Pender and his family in their present severe affliction.*"

The motion was agreed to unanimously.

The CHAIRMAN: Gentlemen, this is unexpected. It is, nevertheless, very soothing to me, and is most sympathetic on your part. I have lost the companion of my life—one who encouraged me in every good work I was engaged in. She was a large shareholder in this Company, and took a very deep and warm interest in everything which promoted, I may say, human progress. I thank you most deeply for your sympathy. I do it, not only on behalf of myself, but also on behalf of my family. Everyone of them has felt this very severe loss. We have felt that the sunshine has departed from our home; but, nevertheless, we believe that the noble example she set to us all will be a model for us to follow in our path through life. I thank you for the way in which you have adopted the report, and for the vote which you have awarded the Chairman, Sir James Anderson, and the Board. I can only say, from a most perfect knowledge of the wishes, the desires, and abilities of the gentlemen who sit on this side of the table, that they are proud of the position they occupy. They are proud of it because this system has become, probably, the most useful and civilising institution that exists on the face of the earth at the present moment. The work that we have done in promoting political, commercial, and social progress throughout the world cannot be measured. Therefore, whatever may be said, there is to be said for the Board that they are doing their duty faithfully and honestly, and the shareholders are reaping the reward of their exertions.

The proceedings then terminated.

The South of England Telephone Company (Limited).

The seventh ordinary general meeting of this Company was held on the 18th inst., at Winchester House, 50, Old Broad Street; Mr. D. Owen Bateson presided.

The SECRETARY (Mr. Fred. L. Robinson) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen,—My first business to-day is to explain why the report and balance-sheet of the Company have been delayed this year beyond the time they have usually been issued. Many of you are aware that our licence from the Post Office is only terminable at periods of seven years, by the Postmaster-General giving us six months' notice. The first of these periods expires on the 31st December this year; and as notice has not been given us the Company have now another term of seven years of life before them. It was thought undesirable that the condition and progress of our business and our figures should be produced while this was in abeyance; but as soon as the Postmaster-General announced that he had no intention of moving in the matter we have lost no time in handing our report and in calling you together. I may add that there has been no delay on our part, as our books were balanced and our accounts made ready for the auditors within about six weeks of the termination of our year, viz., April 30th. I have no doubt but that next year we shall revert to our usual time of holding our annual meeting. I should also like to state why we did not pay our Preference dividend at the beginning of May, as in former years. Some of our shareholders expressed a doubt as to whether the plan we had previously adopted was correct, arguing that though right enough to pay an interim dividend on an estimate of profits, it was hardly businesslike to make a final distribution before the correct balance had been ascertained and audited. This view being considered reasonable by your Directors, they have adopted it. Your Directors have nothing to complain of as to the progress of the business. The increase is not very rapid, but it is continuous and steady, and considering the somewhat bare pasture which we cultivate, we have, we think, fair reason to be satisfied. I am sorry to say that the National Company apparently do not see their way to admitting our subscribers to their system; this debars us from exploiting the most valuable part of our district, viz., that which lies within a radius of 20 miles or thereabouts from London. There are many residents and firms who are most anxious for this communication; and I do not think this connection of the two systems can be very long delayed, as I am sure it would be much appreciated, and, what is more to the interest of the telephone companies, it would be extremely profitable. Our trunk line system in East Kent will shortly be completed by the erection of a route between Ashford and Canterbury. This will enable the former town to communicate with almost all the centres of business and sea-side towns in the district. We have to thank Lord Winchilsea for granting us the wayleave through his large estate at Eastwell Park, and thereby facilitating our running this line. The cost of wayleaves is increasing year by year; though as a rule they are accorded to us without much difficulty, we are occasionally squeezed unmercifully. When we find this is being done we prefer altering our routes, if possible, even at considerable extra expense, rather than give way to undue pressure. The rating question, too, is becoming a serious matter for telephone companies, and in many of the towns in which we work this question has been raised. In Brighton we appealed to the Quarter Sessions against what we considered an excessive assessment, but unfortunately did not get it reduced. It ought really to have been carried to the Queen's Bench for a final decision; but as the parent Company positively declined to bear any portion of the expense for so doing, we did not think it well to spend any more of your money in a matter that, being for the general good, we considered ought to be paid for out of the common purse. No doubt the question will come up again elsewhere, and will have to be fought out. Our hope is that this will not occur in our district. As regards our accounts, those of you who have analysed the figures will have seen that our gross rentals have increased £3,676. This is about our usual average. This year, however, the shareholders derive no benefit from this improvement, as our auditors have made a great point of our carrying a much larger proportion of our wages and office expenses to revenue than our auditors last year thought necessary. It was considered, too, that the reserve ought to be increased, as this item has not been altered for some years. No doubt they were right to some extent, as the older the Company grows there must of necessity be an increased amount expended on repairs of lines, altering routes, &c. This we quite admitted, and provided for in the balance-sheet we submitted; but our auditors were apparently resolved that all our increase for the year should be placed to maintenance. Your Directors thought, and still think, that so large an addition as £3,753 to maintenance was unnecessary and inequitable; but as a clean certificate was refused us, and we were threatened with a contentious meeting if we did not, we thought it well unwillingly to agree to the inevitable, and present the figures which you have before you, leaving the matter in your hands. There is little doubt that the alterations strengthen the financial position of the Company; and though for a time it is probable that the selling value of the ordinary shares may be depreciated to some small extent, that of the Preference shares ought, at least, to be maintained, as they are, to my mind, a steady and reliable security. I do not think there is any other matter in the accounts that needs explanation; all the figures seem to me to be easily understood. However, I shall be glad to make anything clear that appears to be in any measure obscure.

A SHAREHOLDER asked whether there were any negotiations pending between them and the National Telephone Company with a view to buying up the Company.

Another SHAREHOLDER stated that he noticed the National Company, in their report, valued the shares they hold in this Company at 5s. each. He hoped the Directors would not enter on any negotiations at such a figure or anything like it.

The CHAIRMAN replied that they had never been approached on this subject, nor had they asked any price yet for the shares. The Chairman of the National Telephone Company had stated that it would be necessary to buy up this and the Western Companies, and that it was entirely a question of price. That gentleman, however, had not said that there were any negotiations pending, as the shareholder who asked the question seemed to think. When the time came they would be glad to receive a fair offer, but of course nothing would be done in the matter without consulting the shareholders, for which they would be called together. He concluded by moving:—

"*That the report and accounts for the year ended 30th April, 1890, now presented, be adopted and passed.*"

Mr. ALEXANDER MACGREGOR seconded the resolution, remarking that the placing of a large sum to the reserve account was a wise policy, and would conduce to the interests of the Company.

The resolution was carried unanimously.

The CHAIRMAN next moved:—

"*That a dividend at the rate of 6 per cent. per annum for the half-year ending 30th April, 1890, on the Preference shares be now declared payable on the 19th inst., making 6 per cent. for the year.*"

Mr. CHARLES BILLETT seconded the motion, which was carried unanimously.

The CHAIRMAN moved:—

"*That a dividend at the rate of ½ per cent. per annum on the ordinary shares be now declared, payable on the 19th.*"

Mr. BILLETT seconded the resolution, which was agreed to, *nem. con.*

Mr. WILKINS asked what interest was paid on the amount received in anticipation of calls.

The CHAIRMAN replied that it was a matter of bargain, but in all cases they had received the money at 5 per cent

Mr. MARSHALL proposed, and Dr. ELLIS seconded, the next resolution as follows:—

"*That the sum of £200 be paid to the Directors for their services during the year ended 30th April, 1890.*"

The resolution was carried unanimously.

On the motion of Mr. BILLETT, seconded by Mr. MACGREGOR, the Chairman was re-elected to his seat at the Board; and the CHAIRMAN having briefly acknowledged his re-appointment, Mr. J. Weise, the shareholders' auditor, was re-elected, and the proceedings terminated.

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United River Plate Telephone Company (Limited).

The fourth annual ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on the 22nd inst.; under the presidency of J. Irving Courtenay, Esq.

The SECRETARY (Mr. J. Owen Unwin) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: It is now my duty, in the absence of Lord Thurlow, to address some observations to you before I move the adoption of the Directors' report and the balance-sheet. My task on this occasion is not an easy one, for to all those who are interested, and they are many, in the Argentine Republic, the financial position of affairs in Buenos Ayres cannot but be a matter for much anxiety; but from the best information I can get, and you are aware that this Company is fortunate in numbering amongst its Directors several gentlemen who have spent a good part of their life in the River Plate, and who are, therefore, thoroughly acquainted with the country, I have a full belief that, with a prudent administration of its affairs, the natural resources of the country are so great that it will rapidly surmount its present difficulties. The gross income for the year shows a large increase, as it amounts to £108,612. 2s. 7d. for the year ended the 31st March, 1890, as against £81,866. 2s. 4d. for the previous twelve months. These figures need no comment; they speak for themselves, and show how largely our business has grown and developed during the past year. There has been a considerable rise in the working expenses, which has been caused mainly by a large increase in wages and an increase in the cost of materials. We have fortunately avoided any serious dispute with our *employés*, but, as in the case of other River Plate Companies, the depreciated currency has rendered a considerable increase in the wages account absolutely unavoidable, while the cost of our materials has naturally been greater. There has also been some increase in taxation. These several increases in expenditure have caused an increase in the percentage of working expenses. There is also a special item of expense this year, caused by the repairs rendered necessary by a cyclone in Rosario in December last. The grave loss of the Company, however, as you will observe from the profit and loss account, is the loss on exchange, which is the cause of your reduced dividend, and is a matter entirely beyond the control of the Directors; it amounts to no less than £22,334. 17s. 1d. as against the loss last year of £14,689. 6s. 8d., or an increase of £7,645. 10s. 5d. The total loss on exchange is, therefore, about 8 per cent. on the paid-up capital. The result, after paying all working expenses, debenture interest, and general charges, both in the River Plate and in London, is a profit of £34,198. 6s. 5d., from which deducting the loss on exchange, viz., £22,334. 17s. 1d., there remains a net profit of £11,863. 9s. 4d., which, with the balance from last year of £1,210. 7s. 2d., amounts to £13,073. 16s. 6d. We paid an interim dividend of 2 per cent. (£5,800) in January, and we recommend a further payment of 1 per cent. out of the balance. We propose to carry £2,000 to depreciation and renewal fund, which will then stand at £9,000, and to carry forward the balance of £2,373. 16s. 6d. In view, then, of the abnormal position of business in the Argentine Republic, which has existed for some time past, I think you will agree with me in considering the results obtained to be fairly satisfactory, and I hope that you approve of the policy of the Directors in carrying forward a substantial balance to next year. I will now proceed to point out a little more in detail some of the encouraging features in connection with the Company's business in the Plate. At the date of the balance-sheet, namely, March 31, 1890, the number of subscribers in Buenos Ayres and Rosario was over 5,000. You will remember that the Company commenced business with about 3,000 subscribers. There has been, as might be expected during such a crisis, a number of people who have given up their telephones; but, on the other hand, there has been every month a steady influx of new subscribers, and the business of the Company has shown, in spite of the financial crisis, a remarkable vitality. I have no hesitation in saying that this most satisfactory feature has mainly been brought about by careful and vigilant administration, and by the excellence of the service the Company gives to its subscribers, both at Buenos Ayres and Rosario, and in this connection I will read an extract from a letter from one of our Buenos Ayres representatives, in which he says:—"We are giving a service such as we can safely say has never been given in Buenos Ayres before; of course, we have complaints, but they are brought down, we think, to a minimum, and are neutralised by the many expressions of satisfaction that we hear on all sides." I am sure you will agree with me in thinking that we may congratulate ourselves on having such painstaking and zealous representatives as Messrs. Fels and Krabbé at Buenos Ayres, and Mr. Chappell at Rosario. The Directors have during the past year carried out successfully what they hinted at in their report of 1889, and have raised the rates of subscription, with the view of meeting to some extent the increased expenses and charges incidental to the condition of the currency and business generally in the Plate. The capital outlay for 1889-90 is £7,297. 14s. 11d. less than it was in 1888-89, even after deducting from the outlay of the last period the cost of the purchase of the Rosario business; and I may here remark that the Directors have not overlooked the question of the construction of the Rosario trunk line when a favourable opportunity presents itself. The issue of Five per Cent. Debenture Stock, and the conversion of the Seven per Cent. Debentures, as authorised by the Extraordinary General Meeting in January of this year, has been satisfactorily carried out, and was evidently appreciated by the shareholders. I believe I have now touched upon most of the important points, but if there are any upon which the shareholders desire further information, I shall be happy, as far as lies in my power, to meet their wishes. I cannot conclude without expressing my confidence in the future of the Company; I think it is evident that its business is steadily improving, and, therefore, when this crisis has passed away we shall reap the fruits of the solid progress that has been made, and the substantial position that we have been able to reach, in spite of the financial obstacles that we have had to encounter and are encountering; and I may add that our receipts for the first quarter in the new year, April to June, have, as we know by telegram, been larger than in any previous quarter since the Company commenced. I now beg to move:—

"*That the report and accounts submitted to the meeting be, and they are, hereby received and adopted by the Company, and that the Company declare the dividend recommended in such report.*"

Mr. FRANK W. JONES seconded the motion.

Mr. PEEL congratulated the Directors on the present position of the concern, the progress of which was clearly evidenced by comparing the figures of the past year's working with those of the previous year.

Dr. ELLIS said he noticed that there had been a very large increase in the business of the Company, but he wished to know whether this increase had been caused by the acquisition of the Rosario business. Last year they paid a dividend of 6 per cent., whereas he calculated that this year they would only have had enough to pay 5 per cent. if the rate of exchange had remained the same. They had a depreciation and renewal fund, and he thought that the expenses caused by the cyclone, to which reference had been made by the Chairman, should have come out of this fund, and that they ought not to hear of such an event causing an increase in their working expenses. He felt sure, with the previous speaker, that the best had been done for the shareholders, and that they had no cause of complaint. That that, too, was the general feeling of the shareholders was clear by the small number who had attended. He had certainly expected to see more shareholders present in face of the reduced dividend; and the small attendance clearly proved the confidence of the shareholders in the Board.

The CHAIRMAN: The Directors are very much obliged to Mr. Peel and Dr. Ellis for the kind expressions they have given utterance to. Of course the Rosario business does go into the accounts; but, quite apart from the Rosario business, there has been a considerable and very satisfactory increase in the Buenos Ayres business. I do not think it is advisable to give the precise figures of the increase in our new subscribers. As I have said, we have had to increase the rates of subscription. We were told that this would do a great deal of harm, but I am glad to say that it has by no means caused the harm which some people anticipated. There has been a considerable increase in the number of the subscribers, and I think that it is an increase which we have every reason to be satisfied with in the circumstances which have prevailed, and the state of business in the country. Not only did a rise of wages occur, but there was also an increase in the cost of material. There is no doubt that this has told on us very decidedly. Supposing the rates had not been increased, we should not have done so well in regard to the question of dividend. I took note about the observation that was made as to charging the expenses of damages done by cyclones to the depreciation and renewal fund; but I hope we shall have no more cyclones to charge against anything. We want, however, to have a good depreciation and renewal fund, and we thought it right to charge the expenses of this particular storm against the revenue. We will bear in mind your remarks on a future occasion, but I think we ought to have a strong reserve fund. I think we can see from the tone of the gentlemen who have spoken and the feeling of others with whom we have communicated that they approve our cautious policy in trying to build up this Company. We all feel the loss of dividend, and I should have been very pleased if we could have paid more. I am, however, glad that you approve our policy of not dividing up to the hilt. He then put the resolution in the usual manner, and it was carried unanimously.

On the motion of the CHAIRMAN, seconded by Dr. ELLIS, the retiring Directors, Lord Thurlow and Mr. Frederick Green, were re-elected; as were also the Auditors, Messrs. Cooper Brothers and Co, on the motion of Mr. BISHOP, seconded by Dr. ELLIS.

A vote of thanks to the Chairman and Directors brought the meeting to a close.

Exeter Electric Light Company (Limited).

The second annual meeting of the shareholders of the Exeter Electric Light Company was held at the Company's works, New North-road, on Tuesday; Mr. W. H. Ellis presiding.

The following is an abstract of the Directors' report:—"The numerous difficulties which are inseparable from the commencement of every Electric Light Supply Company have been successfully overcome. The property which your Directors secured on such advantageous terms as a site for the central station has been thoroughly adapted and fitted up for the purpose, for which its position makes it most valuable. The plant laid down, which has been selected with great care by Mr. Massingham, the Managing Director, and the Electrician-in-Charge, is of the highest possible efficiency and in excellent working order, as is testified by the fact that during the last six months no customer has been deprived for a single hour of the light for which he pays. The accounts show a profit of £165. 6s. 7d., which your Directors recommend should be carried forward. That any profit should have been made must be considered satisfactory, seeing the short time that the station has been in anything like working order, and that neither the arc nor incandescent dynamos are yet being worked to their full capacity. The Company being now well established, and the supply of the electric current perfect, there is every reason to expect that during the next six months all the additional lights which the machines are capable of supplying will be taken up by customers, which would produce a good dividend, to be augmented as the demand for light increases and additional plant is laid down. It has been considered desirable to apply to the Board of Trade for a Provisional Order authorising the Company to supply electricity in Exeter, and the necessary

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preliminary notices have accordingly been given. This order will place the Company in a more advantageous position for extending its operations, and will empower it to place the mains underground."

The CHAIRMAN moved the adoption of the report, which, he said, they must all feel to be exceedingly satisfactory, considering the short time the Company had been running. He could not help thinking that everyone who had the chance of having the electric light would do so when they considered the great advantage there was to be derived from using it in point of health.

Mr. MASSINGHAM seconded, and said he considered the report was highly satisfactory.

The motion was agreed to; and Mr. Knill having been re-elected auditor, the meeting closed with votes of thanks to the Chairman and Directors generally.

Crompton and Co. (Limited).

The second annual general meeting of the members of Crompton and Co. (Limited) was held at the City Terminus Hotel, Cannon-street, on Monday last, under the presidency of Mr. R. E. B. Crompton.

The SECRETARY (Mr. Francis R. Reeves) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: Gentlemen,—I feel very greatly my position in having to take the place of my lamented friend, Lord Torrington, who died since our last meeting. The matter is a personal one to me, because he was my greatest friend in the world; and his loss to you also is very great, for he was a man who took a keener interest in your affairs than I have ever witnessed any other Chairman do. We are finding it extremely difficult to replace him. At the date of the last meeting the whole of your Preference shares were not placed. There still remained 1,200 of them unallotted, but these we placed shortly after that meeting. Thereupon, it became the duty of the Directors, in accordance with the promise contained in the prospectus, to make an application to the Stock Exchange for a quotation of and settlement in the Preference shares. The Stock Exchange Committee found the papers and books in order, but it required an unimportant alteration to be made in the Articles of Association. To effect this alteration the shareholders were called together, and the necessary special resolution having been passed and confirmed the Stock Exchange Committee granted the application, and the shares are now quoted in the official list. There have not been many sales of shares during the year, judging from the transfer books. The explanation of this is that the shares are firmly held, and that the shareholders do not wish to part with what they believe to be a good dividend-paying property, and moreover they appear to be worth more than their present list quotation. The business of the Company has increased very largely during the year, and has compelled the Directors to look for more capital for the increase of plant at Chelmsford and elsewhere, and for increasing the working capital. They therefore decided to exercise the borrowing powers vested in them by the Articles, and to issue Five per Cent. Debentures to the amount of £50,000. These debentures are secured by a deed of mortgage vesting all the property of the Company in trustees for the debenture holders. In the prospectus of the first issue we offered £25,000, which has all been applied for; but the Directors now propose to offer the remaining £25,000 among the shareholders; and a circular to this effect will be sent out with the dividends this evening. The debenture debt is the only charge upon the property. The shareholders will see by the statement before them that the profit of the last year was £10,610. 1s. 7d., which is an increase of £2,000 over the amount earned last year, and about £4,000 greater than the average profit for the six years preceding the formation of the Company. This result must be considered fairly satisfactory. After the payment of the interim dividends, providing for debenture interest and other charges, and setting aside £500 for doubtful debts, there remains £5,530 available for dividend; and out of this sum the Directors propose to pay 7 per cent. per annum on the Preference and 5 per cent. per annum on the ordinary shares of the Company, carrying the balance, £474, forward. As I have already stated, the increasing business of the Company has necessitated capital expenditure both on buildings and plant, as well as on tools and extensions at Chelmsford and the starting of London works. The Company have also taken over a portion of the property which was leased to Messrs. Crompton and Fawkes, which is immediately available for the extension of the Chelmsford works. In London during the past year we had the good fortune to secure very large orders from three of the most important supply companies. The nature of these orders is the supplying and fixing of central stations, and of a complete system of underground mains, extending over 40 or 50 miles of London streets. During the early portion of last year we worked with a separate staff from temporary premises on the Kensington Court estate; but as these premises were no longer available the Directors thought it advisable to lease convenient ones on a longer tenure. They have taken a lease of No. 1, Lillie-road, West Brompton. These premises are sufficiently large and convenient for our purpose. They are now in process of being fitted up, and are nearly completed, and they are the head-quarters of the engineering staff in connection with these large West End orders. The principal feature of these orders is that there seems to be a fair chance of a good profit being made on them, and the risks in connection with them are not large. The order books of the works are full of our own specialty—dynamo machines, switchboards, and that class of plant. Further than this, the general prospects of orders are better, I think, than I have ever known them since I have been in the electric light business. I think we may congratulate ourselves on the extremely good feeling which is prevailing between ourselves, our staff, and workpeople. We have succeeded in organising piecework on the most considerable scale that we have yet attempted, and that without meeting with the difficulties that other engineering firms have had to contend against. I think that a great deal of this is due to the tact and good management of our Chelmsford managers, who have succeeded in carrying out this difficult work without in any way causing ill-feeling. We know that this very delicate subject of piece work has been the bone of contention which has caused so many strikes all over the country. I need hardly tell you gentlemen, that a successful work of this kind is a great step in advance, as it enables us to keep accounts and to know the cost of our work with much more accuracy than was possible to be the case with the greater part of the work when done by day labour. As to the annual statement of accounts themselves, I do not think that there is anything which calls for special comment; but should any shareholder desire any further explanation, I shall be glad to give it. I will conclude by moving—

"*That the report of the Directors and the audited statement of accounts for the year ending March 31, 1890, be, and the same are hereby, approved and adopted.*"

Sir CHARLES GRANT seconded the motion.

Mr. T. R. TUFNELL expressed his great satisfaction with the way in which everything was conducted at the Company's offices. He called several times on various matters, and the explanations were perfectly satisfactory.

The SECRETARY, in answer to Mr. COX, said that the accounts of the Australian Company had not yet reached England, but one of the managers was on his way with them. Meanwhile, they had learned that the accounts showed a satisfactory profit.

The resolution was carried *nem. con.*

The CHAIRMAN moved, and Mr. C. F. TUFNELL seconded, the next resolution, as follows:—

"*That a dividend at the rate of 7 per cent. per annum for the half-year be declared and paid on the Preference shares of the Company.*"

The motion having been unanimously approved,

The CHAIRMAN moved, and Mr. GIBSON seconded:—

"*That a dividend at the rate of 5 per cent. per annum be declared and paid upon the ordinary shares of the Company.*"

The motion was agreed to *nem. con.*

The CHAIRMAN moved:—

"*That Sir Charles Grant be, and he is hereby, re-elected a Director of this Company.*"

I can hardly say how much the Managing Directors were indebted in the past for the advice and assistance of Sir Charles Grant, who has acted as our Chairman since the death of Lord Torrington. I am occupying this position to-day chiefly on account of my long connection with the business, and because of my intimate acquaintance with the details; but Sir Charles Grant has been a powerful and steadfast man, on whom we Directors have had to rely, and I should feel it very much if he left the Board of this Company.

Mr. ALBRIGHT seconded the resolution, which was carried unanimously.

On the motion of Mr. TUFNELL seconded by Mr. DRUMMOND, the auditors, Messrs. J. H. Duncan and Co., were re-appointed; and a vote of thanks having been accorded to the Chairman and Directors, the proceedings terminated.

Anglo-American Telegraph Company (Limited).

Report of the Directors to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, 50, Old Broad-street, E.C., on Friday, the 1st of August, 1890, at two p.m.

The total receipts from January 1st to June 30, 1890, including the estimated balance of £2,247. 12s. 8d. brought forward from the last account, are estimated at £152,989. 7s. 11d. This amount, however, is subject to revision, as the lawsuit between this Company and the Paris and New York Telegraph Company is still pending. The traffic receipts show an increase of £2,025, as compared with the corresponding period of last year.

The total expenses of the half-year, including the new offices in New York, repair of cables, &c., as shown by the revenue account, amount to £53,945. 9s. 7d.

One quarterly interim dividend of 12s. 6d. per cent. on the ordinary stock, and of 25s. per cent. on the Preferred Stock, was paid on the 1st May, 1890, absorbing £43,750, and a second quarterly dividend of 15s. per cent. on the ordinary stock, and £1. 10s. per cent. on the Preferred Stock, will be paid on August 1, 1890, amounting to £52,500, leaving a balance of £2,793. 18s. 4d. to be carried forward to the next account.

The Company's repairing steamship "Minia" has been engaged during the past half-year in the repair of the Northern Placentia cable, near Placentia, and of the St. Pierre-Duxbury cable 270 miles from St. Pierre. The vessel was chartered to the Direct United States Cable Company on two occasions for executing repairs, the remuneration for which will be found in the revenue account.

The Company's cables and land lines are in good working order.

Three new offices have been opened in New York, viz.: No. 8, Broadstret, 16, Beaver-street, and 446, Broome-street. The results are encouraging.

No progress has been made since the last report in the litigation between the Anglo-American Telegraph Company and the Paris and New York Telegraph Company, the appeal to the Conseil d'Etat not having come on for hearing.

The agreement between the Société du Cable Transatlantique Français (amalgamated with the Anglo-American Telegraph Company in 1873) and the Submarine Telegraph Company, for the laying, maintenance and work-

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ing of the cable used by this Company from Brest to Salcombe expired on the 31st March, 1889. The French and English Governments bought the Submarine Telegraph Company's property, with the exception of the cable above referred to, and after long negotiation this Company has purchased the Brest-Salcombe cable from the liquidators of the Submarine Telegraph Company for the sum of £2,000, and by arrangement with the Associated Cable Companies this Company now maintains and works the cable for an agreed annual payment, which forms a charge upon the joint purse payment.

Globe Telegraph and Trust Company (Limited).

The following is the report of the Directors, to be presented to the seventeenth ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., on Tuesday, July 29, 1890, at 1 p.m.

The net revenue of the Company for the year ended July 18, 1890, after deduction of expenses, amounts to £193,499. 4s. 10d., which, with the balance of £2,054. 10s. 6d., brought forward, make a total of £195,553. 15s. 4d. From this amount there has been distributed the sum of £130,806. 5s. 8d. in interim dividends, leaving an available balance of £64,746. 9s. 8d.

The Directors recommend the payment of a final dividend for the year of 3s. per share on the Preference shares, and of 4s. 3d. per share on the ordinary shares, making, with the former distributions, a total dividend for the year of 6 per cent., less income tax, upon the Preference and 5 per cent. net upon the ordinary shares (against 4⅝ per cent. for the preceding year), and carrying forward a balance of £118. 18s. 6d.

Since the last report 80 shares of the German Norwegian Company have been drawn for amortisation and paid off at par less exchange. It is probable that this cable may be acquired by the German Government within a short period. £890 stock of the Submarine Telegraph Company has been paid off, at 107 per £100 stock; there is still a small return to be made by the liquidators. £200 of the Société Carmichael has been paid off. A further 350 American Cable Company's ($100 fully paid) Shares, with 5 per cent. guarantee of the Western Union Company of New York, have been added to the investments.

The Directors record with much regret the loss of their colleague, the late Sir Daniel Gooch, Bart. They have elected Mr. James Pender in his stead.

In conformity with the Articles of Association William Ford, Esq., and Sir Henry Daniel Gooch, Bart., two of the Directors, retire; but being eligible, offer themselves for re-election.

The auditors, Mr. John George Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths, and Co.), and Mr. William Griffith, B.A., Barrister-at-Law, also retire at the meeting, and offer themselves for re-election.

Telephone Company of Austria (Limited).

Report to be presented at the seventh ordinary general meeting of the Company, to be held at the offices of the Company, 53, New Broad-street, on Thursday, the 31st July, at 4 p.m.:—

During the year ended 31st March, 1890, there has been expended on capital account a further sum of £10,155. 11s. 10d. The gross receipts from all sources were £16,524. 8s. 8d. After providing for all expenses, including £5,425. 4s. 2d. for debenture interest and dividend on preference and interim dividend of 2½ per cent. on ordinary shares, and £3,032. 0s. 9d. for royalties and taxes to the Austrian Government, there remains a balance of £1,640. 12s. 7d., which, with the amount £3,284. 4s. 6d. brought forward from last year, leaves to the credit of profit and loss account for the current year the sum of £4,924. 17s. 1d.; of this amount it is proposed to place £3,000 to reserve, and to pay a further dividend of 1½ per cent. upon the ordinary shares (making 4 per cent. for the year), leaving £1,047. 2s. 7d. to be carried forward to the next year's accounts.

The Directors are much pleased to again report a continued increase in the number of subscribers to the Company's exchanges, as shown by the following table:—

	No. of subscribers.	Increase over previous 12 months.	Rental.	Increase over previous 12 months.
31st March, 1889	... 2,299	... 263	... 182,550 fl.	... 20,749 fl.
31st March, 1890	... *2,652	... 353	... 210,000 fl.	... 27,450 fl.

* Exclusive of 216 "Extension" telephones which were erected during the year, giving an additional annual rental of fl7,220.

Installations in the towns are still progressing at the usual rate, and, so far as the Board can judge, seem likely to continue to do so. The calls of subscribers now average over 70,000 per week, as against 64,000 last year.

The Government trunk line between Vienna and Prag, which was alluded to in the last report, was successfully completed and opened for the use of the public towards the end of last year. The undertaking has proved a very great success; and, although the outlay to this Company for new switchboards, &c., was considerable, we have reaped the benefit of a fair increase in the number of new subscribers joining the exchange system. The Austrian Government have now in contemplation the connecting up of other towns worked by this Company, on the same terms as the Vienna-Prag Line, *i.e.*, the Government constructs the trunk line and places the Company's exchange subscribers in communication with Vienna, the Company having the indirect benefit of the increase of subscribers.

In relation to the prolongation of the Company's concessions, the Minister of Commerce has fixed the month of October for opening the negotiations, which, your Directors have every hope, will be of a satisfactory nature to the shareholders. Mr. R. Howard Krause, General Manager, visited London in February last, when the details were fully discussed with him, and it is from his statements that the Directors have every confidence in a satisfactory settlement being arrived at.

The cordial and satisfactory relations of the Imperial-Royal Telegraph and Postal authorities and of the municipal bodies with the Company remain unaltered.

The thanks of the shareholders are again due to Dr. Eugen Weissel for his continued valuable services during the past year, and to Mr. Krause for the very satisfactory manner in which he continues to perform his duties as General Manager.

Mr. R. E. Bateman retires by rotation from the Board, but being eligible, offers himself for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also retire, but being eligible, offer themselves for re-election.

Edison and Swan United Electric Light Company (Limited).

The following is the seventh annual report of the Directors, to be presented to the shareholders' meeting at the Cannon-street Hotel on Monday, July 28, at 12 noon.

The business of the Company for the year ending June 30, 1890, has resulted in a credit balance of £61,115. 3s. 3d. Of this amount £12,371. 14s. 7d. has been absorbed by the payment of an interim dividend on the "A" shares, at the rate of 7 per cent. per annum, for the first six months of the year. The Directors recommend the payment of the following dividends on the "A" shares, free of income-tax, and to be distributed in accordance with Clause 87 of the Articles of Association:—(*a*) At the rate of 7 per cent. per annum for the half-year ended June 30, 1890 (making 7 per cent. for the year); (*b*) 4 per cent. in completion of payment of arrears of cumulative Preference dividend for the year ended June 30, 1884; (*c*) 4 per cent. in respect of arrears of cumulative Preference dividend for the year ended June 30, 1885; which will absorb £40,649. 19s. 3d.; leaving £8,093. 9s. 5d., which the Directors have carried to the reserve fund, in accordance with Article 89 of Articles of Association.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
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VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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The Directors have been adding to the buildings and plant at the factory, so as to enable them to manufacture lamps in sufficient numbers to meet the demand which will arise as the supply companies extend their operations in London and other towns.

Mr. Shelford Bidwell, F.R.S., retires from the Board, and offers himself for re-election as a Director. The auditors, Messrs. Welton, Jones, and Co., retire, and are eligible for re-election.

NEW COMPANIES REGISTERED.

AMALGAMATED ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by Slaughter and May, 18, Austinfriars, E.C., with a capital of £100 in £5 shares. Object, to carry on the business of electrical engineers. Registered without Articles of Association.

ELECTRICITY SUPPLY COMPANIES' UNION (LIMITED).—Registered by Slaughter and May, 18, Austinfriars, E.C., with a capital of £100 in £5 shares. Object, to carry on business as electrical engineers. Registered without Articles of Association.

UNITED ELECTRICITY SUPPLY COMPANY (LIMITED).—Registered by Slaughter and May, 18, Austinfriars, E.C., with a capital of £100 in £5 shares. Object, to carry on the business of electrical engineers. Registered without Articles of Association.

CITY NOTES, &c.

BELL'S ASBESTOS COMPANY.—The Directors have declared an interim dividend of 10s. per share for the half-year ending June 30th last, being at the rate of 20 per cent. per annum. This compares with 12s. 6d. per share, or at the rate of 25 per cent. per annum a year ago.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 18th amounted to £4,174.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The Directors have resolved, after providing for the dividend on the Preference shares, and placing £2,500 to the reserve fund, to recommend a dividend on the ordinary shares at the rate of 8 per cent. per annum, tax free, for the half-year ended June 30, leaving £501 to be carried forward.

EASTERN TELEGRAPH COMPANY.—This Company notify that the coupons on their Five per Cent. Debentures due on the 1st August next will be paid on and after that date at the banking-house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C. Coupons should be left at the bank three clear days for examination.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This Company notifies that the coupons on its Six per Cent. Debentures, due on August 1 proximo, will be paid on and after that date at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons must be left three clear days for examination.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.—This Company announces the payment by warrants on August 1st next of interest, for the half-year ending July 31st, on their Four per Cent. Mortgage Debentures. The transfer books will be closed from July 27th to August 1st, both days inclusive.

ELMORE'S PATENT COPPER DEPOSITING COMPANY.—The transfer books of this Company will be closed from July 22 to July 28 inclusive, for the purpose of paying a dividend.

MANGANESE BRASS AND BRONZE COMPANY.—Subject to audit, the Directors of this Company propose a further dividend of 13s. per share, making a total of 20s. for the past year, leaving a balance of £4,030 to be carried forward.

MESSRS. P. AND W. M'LELLAN.—The Directors of this Company have declared an interim dividend at the rate of 6 per cent. per annum on the Preference shares, payable on the 11th of August.

STOCK EXCHANGE.—Application has been made to the Committee to appoint a settling day in and to grant a quotation to the Halifax and Bermuda Cable Company (Limited), £120,000 Four and a Half per Cent. First Mortgage Debentures.

UNIVERSAL AUTOMATIC MACHINES COMPANY.—An extraordinary meeting of this Company was held at Cannon-street Hotel on Thursday last, at which the Chairman intimated that the matters in dispute between the Company and Woodhouse and Rawson United had resulted in the arbitrator reducing the claim of that firm from £19,000 to £11,000, the Company also receiving £8,000 as damages, reducing the claim to £3,000. The business of the Company was now in the hands of a receiver, but negotiations had been entered into lately with substantial parties, and he trusted that shortly an effort would be made for taking over the shares in the Company. A resolution was passed empowering the Directors to accept the best terms possible, which terminated the meeting.

VENEZUELA TELEPHONE AND ELECTRICAL APPLIANCES COMPANY.—The statutory general meeting of this Company was held at Winchester House, Old Broad Street, London, E.C., on the 15th inst.; Sir Douglas Fox presiding. The Chairman said that this was the first statutory meeting of the Company convened for the purpose of complying with the requirements of the Companies Acts, and that there was no special business to transact. It was a great satisfaction to him to be able to state that the number of subscribers for telephones is daily increasing. On December 31, 1889, when the business of the Inter-continental Company was purchased, the total number of subscribers amounted to 1,420, and, according to the last advices from Venezuela, received by cable on June 25, the number of subscribers had increased to 1,681, being 261 subscribers increase in about six months, and there was little doubt that the Company would have 2,000 subscribers by the end of the year. The trunk lines between Caracas and Petare and between Caracas and Antimano are being rebuilt, and it is the intention to extend the former of these lines to Guarenas and Guatire, and the latter to Los Teques. A considerable quantity of material is available at the Company's stores in Venezuela; and this, with further materials already ordered and in process of manufacture will give the facilities necessary for the enlarged business. It is in contemplation to build additional trunk lines between Caracas and La Guayra, and between Valencia and Puerto Cabello, so that there would be seven trunk lines between Caracas and La Guayra, and three between Valencia and Puerto Cabello. With these additional facilities for communication the revenue from these sources should be greatly increased. The Directors had filled up the vacancy on the Board caused by the death of Mr. Francis Bennoch by electing Mr. William Barton Wright. A vote of thanks to the Chairman concluded the proceedings.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended July 15th amounted to £2,879, as compared with £2,553 in the corresponding period of last year.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 18, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,208.

WENDIGO COPPER COMPANY.—This Company has been floated during the past week, with a capital of £62,500 in £5 shares, to purchase a large tract of land situate on Isle Royale, Lake Superior, Michigan, U.S.A., amounting in all to over 5,000 acres, on which extensive beds of copper-bearing rocks have been discovered, and to sink mines for the recovery of the metal. The subscription lists opened on Wednesday and closed on Thursday.

CRICKET.—We are able to give the following particulars of two interesting cricket matches which recently took place at Carcavellos between elevens from the Eastern Telegraph Company's cable steamer "Mirror," and from the Company's staff at Carcavellos. The scores were:—First match: Carcavellos, 109; "Mirror," 36 and 56. Second match: Carcavellos, 117; "Mirror," 18 and 81. It will be seen that the Carcavellos staff won both matches easily—the first by an innings and 17 runs, and the second by an innings and 18 runs—partly due, however to the fact that the visitors were out of practice.

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WAREHOUSE.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

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Sold in sheets, 5ft. 6in. by 2ft. 6in., varying in thickness from 1-50in. to 1in.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 16.	Price Wednesday, July 23.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 23. Highest.	Lowest
£			**TELEGRAPHS.**			£ s. d.			
1,381,380	Stock	1⅜	Anglo-American	50 51	50 51	5 7 10	Jan., Apr., July, Oct	50⅜	50
2,809,310	Stock	25/0	Do. Preferred	86 87	86 87	5 14 11	,, ,,	87⅜	87
2,809,310	Stock	..	Do. Deferred	14¼ 14⅜	14 14½	..	..	14¼	14¼
25,000	£100	4⅞	African Direct, 4 per Cent. Debentures	97 100	97 100	4 0 0	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine	11½ 12½	11½ 12½	4 16 0	Mar., June, Oct., Dec.	12	11¾
69,200	100	5⅞	Do. 5 per Cent. Bonds	102 104	102 104	4 16 2	January and July ..	..	..
75,000	100	5⅞	Do. 5 per Cent. Bonds (2nd Series)	103 107	103 107	4 13 6	June and December	..	..
..	$100	..	Commercial Cables	103 105	103 105	..	..	103½	..
16,000	£10	9/0	Cuba Submarine	12⅜ 13½	12⅜ 13½	6 15 10	February and August	13¼	12⅞
6,000	10	10⅞	Do. Preference 10⅞	17 18	17 18	5 11 1	,, ,,	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3¼ 3⅜	3½ 4	..	March & September	..	..
6,000	5	10⅞	Do. Preference 10⅞	9 10	9 10	5 0 0	April and October..	9¼	..
60,710	20	3/6	Direct United States	10 10¼	10½ 10⅝	6 13 4	Jan., Apr., July, Oct.	10⅝	10⅜
400,000	10	2/6	Eastern	14 14¼	14 14¼	4 11 3	,, ,,	14⅛	14
70,000	10	6⅞	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	,, ,,	15½	15⅞
1,200,000	Stock	4⅞	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	..	..
200,000	£100	5⅞	Do. 5 per Cent. Debentures, 1899	108 111	108 111	4 10 1	February & August	..	..
250,000	10	6/6	Eastern Extension	13⅞ 14⅛	14 14¼	4 18 3	Jan., Apr., July, Oct.	14⅛	14⅛
320,000	100	6⅞	Do. 6 per Cent. Debentures, 1891	101 103	101 103	5 16 6	February & August	..	..
91,800	100	5⅞	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
145,300	100	5⅞	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	100 103	100 103	4 17 1	,, ,,	..	..
180,227	10	2/0	Globe Telegraph and Trust	9⅛ 9⅜	9⅛ 9⅜	5 6 8	Jan., Apr., July, Oct.	9⅜	9⅛
180,042	10	6⅞	Do. 6 per Cent. Preference	15⅛ 15⅜	15⅛ 15⅜	3 18 1	,, ,,	15⅞	15⅛
150,000	10	5/0	Great Northern	15¼ 16¼	15¼ 16¼	4 12 4	Jan., April, and July	16⅜	15⅞
15,000	100	5⅞	Do. 5 per Cent. Debentures, 1881	100 103	100 103	4 17 1	January and July ..	..	..
230,000	100	5⅞	Do. 5 per Cent. Debentures, 1883	105 108	105 108	4 12 7	March & September	..	..
17,000	25	37/6	Indo-European	37 39	37 39	6 8 2	April and October ..	..	..
33,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 15 9	.. ..	..	..
100,000	100	6⅞	Do. 6 per Cent. Debentures	107 110	107 110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7¾ 8¼	7¾ 8¼	6 1 3	April and October..	8¼	..
3,381	£100 Cert.	..	Submarine Cables Trust	112 116	112 116	..	,, ,,	114	..
15,609	£10	5⅞	West African	9 10	9 10	5 0 0	.. ..	..	..
290,000	100	5⅞	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	100⅜	..
30,000	10	2/0	West Coast of America	6 6½	5⅜ 6½	..	January and July ..	5⅜	..
150,000	100	8⅞	Do. Debentures 8⅞	108 112	106 110	7 5 6	June and December	108⅜	..
88,321	10	Nil.	West India and Panama	2⅜ 2⅝	2⅜ 2⅝	..	..	2⅜	2⅞
34,563	10	6/0	Do. 1st Preference 6⅞	11 11⅜	11 11⅜	5 4 4	April and October..	11⅜	11⅛
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12½ 13½	12½ 13½	..	..	..	..
64,572	15	6/0	Western and Brazilian	10 10½	10⅛ 10⅜	5 15 11	May and November	10⅛	10
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	..	..	6⅛	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3½ 4	3⅝ 4⅛	..	..	4	..
200,000	100	6⅞	Do. 6 per Cent. Debentures, Series "A"	106 109	106 109	5 10 1	.. ..	107½	107
250,000	100	6⅞	Do. 6 per Cent. Mort. Debentures, Series "B"	104 107	104 107	5 12 2	February & August	..	..
$1,336,000	$1,000	7⅞	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
175,100	£100	6⅞	Do. 6 per Cent. Sterling Bonds	99 101	99 101	5 18 10	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5⅜	Consolidated Telephone Const. and Maintenance..	⅛ ⅜	⅛ ⅜	..	Yearly	..	..
220,000	£1	3⅞	Oriental (11s. paid)	¼ ⅜	¼ ⅜	4 8 3	Yearly	..	..
386,875	5	3/0	National	5⅛ 5⅜	5 5⅛	..	June and December	5⅛	5⅛
49,825	5	1/4½	Do. New	5¼ 5⅜	.. ..	..	..	..	..
15,000	10	..	Do. 6 per Cent. Cumulative 1st Pref.	12¼ 12½	12¼ 12½	4 14 1	June and December	12⅛	12⅞
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Pref.	10½ 10⅝	10½ 10⅝	5 11 7	,, ,,	..	..
209,750	1	..	South of England, Ordinary	⅛ ..	⅛ ..	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	2⅜ 3⅛	2⅜ 3⅛	..	..	..	..
55,000	5	2/0	United River Plate	4¼ 4⅜	4¼ 4⅜	..	January and July ..	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	..	..	..
100,000	100	7⅞	Do. 7 per Cent. Debentures	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	1⅞ 2⅛	1⅞ 2⅛	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4¼ 4⅜	4¼ 4⅜	..	..	..	..
42,853	5	..	Westminster Electric Supply	1¼ 1⅜	1¼ 1⅜	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	1⅞ 2	1⅞ 2	..	..	..	..
63,416	2	1/2	Do. Preference	1⅜ 1⅞	1⅜ 1⅞	..	..	..	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5¼ 5⅜	5¼ 5⅜	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction	7½ 8	7½ 8⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5¼ 6¼	5½ 6	..	..	5⅝	5⅞
20,000	5	..	Fowler-Waring Cables	2 2½	2 2½	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works. xd	18½ 19½	18½ 19⅜	5 2 7	February & August	18⅜	..
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103 105	103 105	4 5 9	.. ..	..	..
78,949	5	6⅞	Swan United (£3. 10s. paid)	5 5½	5 5⅛	..	..	5⅜	5⅛
37,350	12	36/0	Telegraph Construction and Maintenance xd	43 45	43 45	5 6 8	March and July.....	44	42⅜
150,000	100	5⅞	Do. 5 per Cent. Bonds, red. 1894	100 102	100 102	4 18 0	..	..	..

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(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED

(STATTER'S) Are Proprietors of the above Patent, and Warn the Public against Infringement. (UNITED).

The following are Licensees:—

Brush Electrical Engineering Company, Limited.
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THE ELECTRICIAN:

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ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

Another historical patent has been demolished, and, shall we say another monopoly has been averted? Last week we did not attempt to sympathise with the owners of a patent who had bought it in ignorance of its potential possibilities; but to-day we give in our Legal Intelligence an abstract of the case which, after being pluckily pushed to the highest appeal, has reduced the connection of Gaulard and Gibbs with the transformer system of distribution, to a mere matter of history; and we sympathise with the inventors. In the spring of 1883 a feeble show was held at the Royal Aquarium, purporting to be an Electrical Exhibition. On the first and last occasion on which we visited this establishment, we saw the exhibit of Gaulard and Gibbs, an "arrangement of induction coils" with movable cores—the first transformers ever made and used for the purpose of running electric lamps. No one heeded the invention. It was thought by several, who should have inquired more carefully, that it was proposed to get more out of the coils than was put into them. The experiment on the Metropolitan Railway in the following year convinced very few. Prof. Forbes gave a guarded opinion as to the efficiency, which was much better than was generally expected. With the exception of some good Exhibition work at Turin, we are not aware that Messrs. Gaulard and Gibbs did anything more until the lighting of the Grosvenor Gallery was being arranged. Lord Crawford then advised that the transformer system should be adopted, and a commencement was made under the supervision of Messrs. Brougham and Mackenzie, the transformers being in series, in accordance with the original intentions of the inventors. In due course Mr. Ferranti appeared on the scene, and it was, we believe, he who found that the parallel system of distribution by transformers must supersede the series system, just as the old "series multiple," or whatever it was called, gave way to supply at constant pressure. We cannot go into the origin of the dispute, nor can we inquire into whether the Messrs. Gaulard and Gibbs are to be credited with the invention of transformers, apart from any legal claim which they have made. The fact remains that they introduced them, although their system was as little regarded at first as was that of the parallel distribution of Mr. Lane Fox.

It was unfortunate that the patentees should have stated in their patent that "the number of secondary generators may be indefinitely multiplied upon the circuit," and that "the primary current . . . . is subject to no other modification than is caused by the resistance of the primary coil." This gave Si Horace Davey an opportunity for saying that "thereby t invention claimed was an impossibility, as it would amount to obtaining perpetual motion." It is, however, a perfectly legitimate statement, and one which had probably been verified by experiment. By "resistance" the inventors presumably meant impedance; and they would as naturally provide higher volts for a greater number of generators as they would do if more arc lamps were added to a series circuit.

The history of this case brings again into prominence the exceedingly unsatisfactory nature of the present method of dealing with disputed patents by the ordinary legal tribunals. The Court of Appeal, although declaring the patent invalid on other grounds, held that it had not been anticipated, in which respect the House of Lords have differed from them. This decision was the more remarkable because the objection of the patentees to some of the alleged anticipations was ultimately reduced to this sole distinction, namely, that either in the drawings or the letterpress of the specification referred to, the induction coil to be used was represented with a core apparently made of a solid piece of iron, whereas their own specification stated that the core was made of iron wires. Most people will agree with the evidence given by Sir William Thomson that the reference to a wire core in the specification of Gaulard and Gibbs was a detail which in 1882 it was quite unnecessary to have mentioned at all, because no one would have thought of using anything else. A great deal of evidence and most elaborate arguments were addressed to this particular point, and much time wasted and expense incurred which would have been quite unnecessary before a tribunal versed in scientific matters. Had the case, however, rested solely upon the question of anticipation and the judgment of the Court of Appeal, the electrical trade would have had to face this strange result, namely, that owing to a mere casual mention in a specification filed in 1882 that a certain induction coil, therein described and since admitted to have no special advantages over other coils, was constructed with a core of iron wires, the whole system of distribution by transformers would have been appropriated by the owners of this patent.

We drew attention in our leading article last week to the distinction which Lord M'Laren made between the sufficiency of description which is necessary to constitute publication, and that which is required for a sound patent. The distinction

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seemed to us to be noteworthy; but we are surprised to find that *Industries* considers that "the point was merely technical, and it would be a pity for a patent to be destroyed for an infraction of the letter of the law only, while in complete accordance with the spirit of it." Our esteemed contemporary is apparently referring to BRUSH's patent, as that is the only one which has been destroyed. But where was the infraction of the law? It might have contained a thorough and clear account of compound winding, in complete accordance with both spirit and letter of the law; but it was too late. VARLEY had made a prior publication and prior use. On the other hand, Varley's patent may be meant, since it may be suggested that it infringed the letter of the law, but *it* was not destroyed; its soundness was never questioned, except by some of the witnesses. The decision has not touched on the question of sufficiency of description as a qualification for a good patent; but it decides that if Varley's patent had been utterly worthless in this respect it might yet have constituted a prior publication. Our contemporary says that "to the lay mind, at least, it seems fair that a prior publication, in order to invalidate a subsequent patent, must give full instructions to the 'skilled workman,' whoever he may be." But a very ancient example is that of a lock which was in use on a garden gate for a short time before it was patented. It was admittedly impossible for anyone to have learned any details of its construction; but the fact that it had been exhibited in public was sufficient to invalidate the patent.

THE Bakerian lecture on "The Discharge of Electricity through Gases" by Dr. A. SCHUSTER deals with a subject which is too closely allied to chemical science to allow of an extensive use of mathematical treatment, and is in many respects of so speculative a nature that the results arrived at can only be useful so far as they are corroborated by deductions drawn from other parts of physics. The last section, which the author calls the conclusion, and which we reproduce in another column, hardly does justice to the lecture as a whole. The author grudges the ideas of "stress" and "strain," and objects to the term "displacement." The idea of splitting molecules into ions has always appeared to us to be a mere working hypothesis, which is useful enough in supplying a provisional language for the discussion of electrolytic actions. A definite explanation of the dark space round the cathode of a vacuum discharge and of the stratifications and luminous layers is not to be found in this lecture, and there are several statements which are less orthodox than bold; but if from the positions assumed by Dr. SCHUSTER we can get clearer views as to the nature of electricity, we will not urge objections to theories of its atomic constitution.

A GREAT feature was made by the Standard Screw Gauge Committee of the British Association in their final report, of the fact that the system which they suggested was practically identical with that of the screws in use in the Swiss watch trade, and a concession was made to those countries which use the metric system in defining the gauge in millimetres. The B. A. thread would probably have never been heard of again had not the Telegraph Department of the Post Office taken it up. It is being grudgingly adopted in the electrical trades; but none of the watchmaking firms of the Watch Trades Section of the London Chamber of Commerce had ever heard of it, and evinced no interest in it when it was brought to their notice. A very simple but non-geometrical, and therefore arbitrary, system has been recommended for screws between 0·5mm. and 10mm. by the Congress at Frankfort, whose decisions will be found in another column. The pitch is not far different from that of the B. A. screws of corresponding diameter as given in Mr. KEMPE'S Pocket Book, and the second place of decimals for small screws is avoided. We have no details of the system which has been adopted for heavy engineering; but we doubt whether it should go down as far as 5mm., since the WHITWORTH thread is found to be too coarse for screws of less than ¼in. diameter.

IN the account of the electric lighting at Bath, in our issue of June 27, it was stated that the charge made to private consumers is 6s. per annum for each 10 candle-power lamp, the consumer being free to burn his lamps as many hours as he pleases. A correspondent writes to point out that this appears to be an extraordinary charge. Taking the hours from sunset to 11 o'clock at 1,800, a ten-candle lamp, at 3½ watts per candle, gives 63,000 watt hours per annum, which works out at 1·143d. per unit. We have made inquiries, and find that our statement was quite correct; but our correspondent has not noticed that the charge is made upon every lamp fitted. In all residential houses, and in many other cases, only a small proportion of the lamps are lit at once. No electric supply company in London could meet the demand if every lamp were turned on simultaneously; nor would the gas works fare better. Even if the consumers at Bath get a good six shillings worth during the first year, the fact that they have to pay for the lamp renewals will probably check any reckless waste in the future. If we remember right, it was stated before Major MARINDIN that one hour per night per lamp fitted, might be taken as the average duration of lighting. This would make about one-fifth of the number of watt hours reckoned by our correspondent; and would bring the rate per unit up to nearly 5¾d. Even with coal at 14s. Mr. MASSINGHAM will probably find that he had better turn his attention to the question of meters; but, on the other hand, he has probably gone into this question with reliable data, and in a much more careful manner than either our correspondent or we have done.

AT this time of the year a good deal of our space is occupied at the end of the paper with reports of companies' meetings. As different companies draw up their accounts in different ways, they cannot well be compared; but now that sound business is being done it is interesting to analyse the balance-sheets as far as the details will permit. The share capital of the Edison-Swan United Company is close on half a million, and the value of the patents, goodwill, and development is practically one-half of this. Messrs. CROMPTON and Co.'s patents and goodwill are valued at 20 per cent. of their share capital, including debentures, &c. The former Company appear to set the depreciation of their plant at 8·8 per cent., while the latter includes stock-in-trade,

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and does not give a separate value of the plant; the depreciation on the whole comes to only 2½ per cent. New stock would naturally not suffer depreciation during the current year. The reserve fund of the Edison and Swan Company is 7½ per cent. of their net balance, while that of Crompton and Co. is 12 per cent., and this includes doubtful debts, contingencies, &c. The proportion of net to gross profit is 51½ per cent. in the lamp-making company, while that of the dynamo maker is 41 per cent., but the net profit in both cases includes dividends on external investments. The Directors' and auditors' fees are only 10 per cent. of the earnings of the Edison and Swan Company; these are not given separately in Crompton and Company's statement; but we observe on the other hand, two suspense accounts for new patents and experimental work, which can thus be kept separate from the manufacturing and trading accounts. One cannot expect such companies to discriminate between the value of their patents and that of their goodwill; but we should like to have seen a writing off from the £238,053 of the Edison and Swan patents, instead of an addition of some £2,400.

THE success of the Mining and Metallurgical Exhibition, which was opened at the Crystal Palace on Monday last, is much to be desired on grounds quite apart from those upon which the promoters have built their hopes. So large a population as these islands shelter who are connected with mining industry and metal working is pretty sure to supply a fair contingent of visitors to an Exhibition of such unique and striking interest. But to the public generally, and the investing public in particular, it ought to be useful, not merely as evidence of the mineral wealth that lies buried in the bowels of the earth, but as proof of the enormous difficulties and risks attending the bringing of it to the surface and converting it into a marketable commodity. The hazards of mining, at all events for the nobler metals, have given to it a speculative character from which it will never wholly dissociate itself; but if anything could help to put it on a respectable footing this Exhibition ought to do it—not, however, by raising expectations unduly, but by bringing them down to the level of hard facts. A visit to the shed where the machinery employed in mining industries is at work, ought to disabuse the simplest mind of the notion that the precious ores are anywhere to be had for the mere digging.

ONE of the many excellent suggestions which have been made by the Electrical Trades Section of the London Chamber of Commerce, but one which they found themselves unable to act upon, was the amendment of the clause in the Metropolitan Building Act which limits the size of a building without party walls to 216,000 cubic feet. The London County Council have sought, before a Select Committee of the House of Lords, to introduce an amendment, by which the area may be increased to 450,000 cubic feet. The Corporation of London opposed the amendment on the ground that there would be increased danger from fire. Captain SHAW gave evidence on Wednesday last, and it was decided yesterday to allow 250,000 cubic feet, subject to the consent of the architect of the County Council. A letter from Mr. SLATER to Mr. CROMPTON appeared in our columns on February 7th last.

IT is to be hoped that the report of the Electric Light Committee of the St. Pancras Vestry, of which we give a brief abstract in another column, will be adopted. The action of the first Local Authority that has decided to provide its own electric supply will be watched with interest.

THERE are several points in the remarkable cable accident case recently tried in New York on which further information would be valuable. It is not easy to imagine how the screw of a steamer could become entangled with a cable unless the latter were suspended, and that twelve cables could be chopped up one after the other in this manner by one vessel would be incredible but for the assurance that it had occurred. One would like to know also why the steamer, after breaking, say, half-a-dozen cables, did not take some trouble to clear the remainder, and whether the cables are not marked on the charts of the harbour to enable ships to avoid their locality as far as possible. Then the Judge appears to be under the impression that a submarine cable should be trenched in the ocean bed like a subterrancan land line; and it would be interesting to have his views as to how this could be accomplished. As to the legal aspects of so curious a case one hesitates to express any opinion; but surely, cables laid with the necessary authority have as much right resting on the bottom, whether it be soft or hard, as vessels have in the water; and why the owners of the steamship in question should have been awarded damages it is difficult to see.

Bristol.—The Electric Light Committee of this town have visited Chelmsford and the Kensington and Knightsbridge station.

Telephone Line from Stuttgart to Heilbronn.—This line is being pushed on, and is expected to be in operation within four weeks.

Fire at the Western Union Telegraph Office.—*The Electric Age* gravely offers the suggestion that the Company should have a duplicate plant.

Telephone Operators.—The wages of the lady operators of the National Telephone Company have, according to a letter in the *Financial News*, been raised from 11s. to 12s. per week.

Personal.—The Hon. A. B. Coffin, of the Massachusetts Gas and Electric Light Commission, is now on a European tour. It is his intention to visit the principal gas and electric plants in this country and France.

Telephone in Italy.—The Societa Telefonica Lombarda has had to build an iron structure, 66ft. high, in the Piazetta S. Lepoliro, Mailaud, owing to the householders having declined to allow poles to be put on their houses.

Sofia.—It is intended to light the town of Sofia, Bulgaria, with electricity, using the water of the Boyena as the origin of power. The cost of initial establishment is estimated at £20,000 to £24,000. Tenders will be invited in August.

A Fine Climate.—The *Financial News* says that they are asked to believe that out in Nevada telegraph poles in low places, where water stands in winter, have taken root and are covered with foliage. The poles are cottonwood, and were planted with the bark on them.

Electric Railway at Neustadt.—The Neustadt Cement Works, which already are lighted by electricity, have now built an extension of the railway from the terminus to their works, a distance of 1,700 metres. An electric locomotive draws three trucks each carrying three tons, the journey being performed in ten minutes.

"The Electrician" Annual Dinner.—The seventh annual dinner of the staff of *The Electrician* took place on Monday

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last at the Mitre, Hampton Court. The weather was fine, and a very enjoyable day was spent. An excellent dinner was provided for the 62 members of the staff and visitors, and this was followed by a short programme of toasts and music.

Telephone in the West Riding of Yorkshire.—It is proposed to establish telephone exchanges throughout the West Riding (in the first instance) at greatly reduced rates—probably one-third of the National Telephone Company's charges. The Council of the Keighley Chamber of Commerce have decided to give their heartiest support to the scheme.

Owens College, Manchester.—A special course in electrical technology has been arranged to commence at this College on October 7th. That the instruction will be of a most complete kind may be gathered from the fact that a dynamo house has been built containing two direct and two alternate current dynamos to be used for experimental purposes.

Fulham.—At a meeting of the Vestry the Lighting Committee reported that they had received notices on behalf of the House-to-House Electric Supply Company, and the Stamford Hill, Tottenham, and Edmonton Electric Light and Power Supply, stating their intention to apply to the Board of Trade in due course for electric lighting Provisional Orders.

Extension of St. James's and Pall Mall Company.—At the annual dinner of the St. James's Vestry Mr. Latimer Clarke said that, in addition to the present station of the St. James's and Pall Mall Electric Light Company in Mason's-yard, it was proposed to establish another in the northern part of the parish, from which, in addition to the electric light, arrangements would be made for the supply of a considerable amount of electric power for the purpose of driving machinery.

Barnsley.—At a meeting of the burgesses of the South-West Ward last week, it was unanimously resolved that, having regard to the arbitrary and discourteous manner in which the Gas Company have treated the Town Council, and gas consumers generally, the Corporation should at once put down an installation for the supply of electricity. At a meeting of the Town Council on the 29th ult. it was decided by 15 votes to 5 to proceed with the electric lighting of the inner portion of the town under their Provisional Order.

The Ferranti System in France.—Besides the supply stations at Nancy, Troyes, and Havre, the Société Nationale d'Electricité, which is working M. Ferranti's system in France, has in hand work at Rethel, Vierzon, Nimes, Sens, and Amiens. They are in negotiation with the Municipal Council of Paris for a concession for lighting a portion of the left bank of the Seine, including part of the Fifth Arrondissement and the quartier of Sorbonne. The Company offered a deposit of £4,000, but the Council demand £6,000, and decline to return it.

Gas Companies and Electric Supply.—The President of the Conference of North British Gas Managers in his address at the meeting of the Association at Perth on the 24th ult., after a passing allusion to the experiments made in Greenock of supplying a section of that town with electric light, said it was evident that the electric light could not be supplied at anything like the cost of gas. Gas was the light of all classes of consumers; but the electric light, from its excessive cost, could only be the luxury of the rich. Where gas was sold as cheaply as it was in most towns, there was no risk of the general adoption of the electric light. In his opinion the supply of electricity should be left in the hands of those companies who specially undertook such work, and gas companies should no more trouble themselves with it than they would with the supply of oil to those who prefer to burn this illuminant instead of gas, oil being a much more active competitor than electricity.

Electro-Technical Laboratory at Magdeburg.—At the instance of a number of Magdeburg manufacturers, an electro-technical experimental station is, according to *Nature*, about to be founded in that town, to afford to companies or private persons opportunity of experimenting as to the practicability and cost of various electrical arrangements, and of testing machines, apparatus, &c. The station will be arranged on the pattern of one already in existence at Munich, but expanded in several directions. Dr. M. Krieg, editor of the *Electrotechnical Echo*, will be at its head. Among other matters which will come under its consideration are the examination of arrangements for illumination, transmission of force, and metallurgical purposes, determination of the luminous power of arc and glow lamps, and of constants, such as intensity and tension of current, testing of carbon rods, of measuring instruments, accumulators, primary batteries, &c., examination of conducting and insulating materials, lightning conductors, private telephone arrangements, and so on. Youths devoting themselves to electro-technical work will have opportunities of gaining thorough practical knowledge in the place.

Damage to Cables by a Screw Steamer.—The recent decision by the United States District Court in counter suits brought by the Western Union Telegraph Company and the Inman Line Steamship Company is of interest to submarine cable companies. The propeller of a steamship became entangled with some of the cables landing at Jersey City; twelve cables were broken, and the vessel had to be dry-docked to clear away the remnants from the propeller. The steamship company claimed $2,000 damages and the Western Union over $60,000, and the former won the day. On behalf of the telegraph company it was claimed that they had exclusive right to the silt or mud as a resting place for the cables, and that the propeller caught up the cables from the mud in which they were imbedded. Judge Brown decided that no such right is upheld in the Act of Congress, which permits cables to "go under water, but not so as to obstruct navigation." Nothing in the Act, he asserts, gives any absolute right to lay cables in all cases on the very top even of solid bottom. "There can be no practical difficulty in sinking cables so deeply as not to possibly interfere with the movements of vessels in any and all emergencies of navigation. The use by steamers in the harbour of the undefined margin of silt or mud between the solid bottom and clear water is necessary."

Standard Screw Thread.—The Congress for the standardising of the screws employed in fine machinery (*la mécanique de précision*) took place at Frankfort on June 2nd and 3rd. Several authorities of the German Government, the German Society of Engineers, the Electro-technical Society, and a great number of local associations and institutions were represented. The object, says the *Revue Internationale*, was to arrive at an understanding by which the inconveniences arising from the innumerable kinds and different forms of screws (more than 800) actually employed in fine machinery might be stopped. It will be remembered that the German engineers (that is to say, the representatives of heavy engineering) had previously found themselves faced by the same difficulty, and had established a standard scale down to bolts and screws of 5 millimetres diameter. The Congress adopted the following decisions: 1. The resolutions of the Congress to apply to screws up to 10 millimetres diameter. 2. The thread to have sharp edges (*à arête vive*). 3. The angle of the thread should be 58° 8. 4. The height should be equal to the depth. 5. Only one pitch will be used for each diameter. 6. The usual dimensions will be the following for holding screws (*les vis d'assemblage*):—

Dia. mm.	Pitch mm.	Dia. mm.	Pitch mm.
0·5	0·15	4·0	0·7
0·6	0·15	4·5	0·8
0·8	0·2	5·0	0·8
1·0	0·2	5·5	0·9
1·2	0·2	6·0	1·0
1·4	0·3	7·0	1·1
1·7	0·3	8·0	1·2
2·0	0·4	9·0	1·3
2·3	0·4	10·0	1·4
2·6	0·5		
3·0	0·5		
3·5	0·6		

From 5 to 10 millimetres diameter there will be two scales, one for fine machinery and that of the Society of Engineers. The Congress hopes that the latter will consent to put back the lower limit of their scale to 10 millimetres; if so, the dimensions of the threads will be reduced to one type for each diameter of screw.

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MAGNETISM IN IRON AND OTHER METALS.*—XXV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 309.*)

§ 94. **Later Experiments using the Isthmus Method.**—In subsequent experiments† the induction in iron was forced to much higher values by using a larger electro-magnet and by turning down the neck of the bobbin. The extent to which concentration of induction in the neck may be carried depends on the sectional area of the neck in comparison with that of the pole from which the lines converge. In the following experiment the section of the neck was reduced until it was finally only $\frac{1}{1500}$ that of either pole. The magnet—an exceptionally powerful one, belonging to the Physical Laboratory of Edinburgh University—was excited with 64,000 ampere-turns, and its force was concentrated from poles about 10 cms. square upon a neck or isthmus 2·66 mm. in diameter and 3·5 mm. long. Fig. 67 is a full-size sketch of the poles with the bobbin in its place after its neck had been reduced to the smallest diameter. The dimensions are entered in millimetres. The bobbin *c* was the same bobbin of annealed Lowmoor

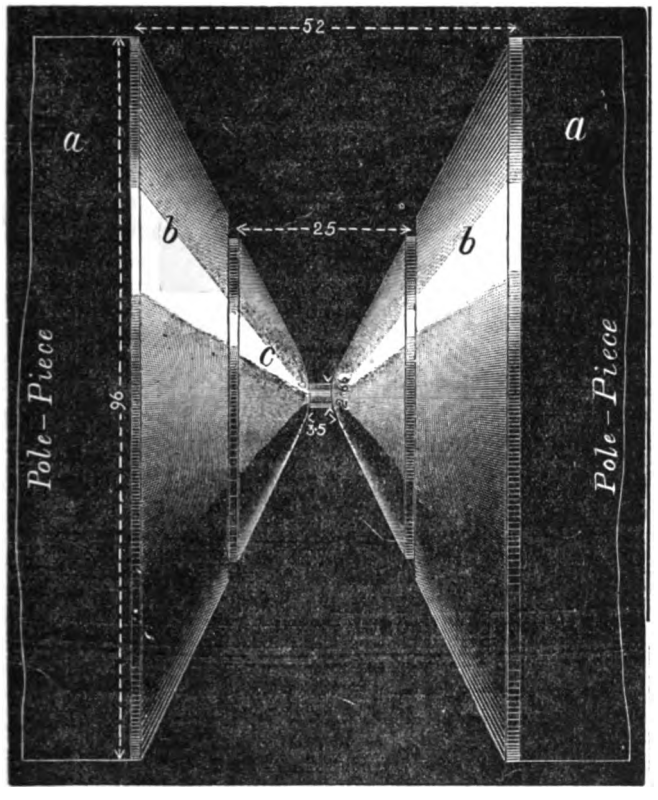

FIG. 67.

wrought iron as had been used in the earlier experiments, a pair of separate conical pieces *bb* being interposed to connect its ends with the pole-faces *aa*. With each reduction in the size of the neck a higher value of B was reached; finally when its diameter was 0·266 mm. the induction B was 45,350, and the force in the space immediately surrounding the neck was 24,500. From other experiments we may infer that this was, as nearly as possible, equal to the actual magnetic force within the metal: hence the result may be written thus:—

H	B	I	μ
24,500	45,350	1,660	1·85

No attempt was made to reduce the neck further, and this is the highest induction that has hitherto been recorded in any experiment. There is no reason to doubt, however, that higher values of H and of B might be obtained by using an electro-magnet of greater size and power.

§ 95. **Theory of the Isthmus Method: Form of Cone to give Maximum Concentration.***—Consider an imaginary section through the middle of the neck, at right angles to the axis of the bobbin. It is clear that there is no discontinuity between the magnetic force, at points in this plane, inside and outside the metal, for there is no free magnetism on the surface of the neck at the middle of its length. We have to consider the conditions which will make the magnetic force as nearly uniform as possible over this medial section in order that the force just outside the neck, which we are able to measure, may be fairly representative of the force inside the neck itself.

The magnetic force in the space between the pole-pieces is made up of two parts: (1) the electro-magnetic force directly produced by the current in the magnet coils; and (2) the force due to free magnetism distributed for the most part over the pole-faces. The first of these forms a comparatively small part of the whole; and its value is sensibly uniform at such small distances from the axis as those with which we are now concerned. In considering the conditions which will secure the greatest strength or the greatest uniformity in the field at the neck, we need only deal with that part of the force which is produced by free magnetism.

The free magnetism of the pole-faces may be treated as made up of a series of co-axial circular rings in planes normal to the axis of the bobbin. Calling M the whole free magnetism of one of these rings (Fig. 68) and r its radius, the magnetic force F due to it at a point in the axis at a distance x from the plane of the ring is $\frac{Mx}{l^3}$ where $l = \sqrt{r^2 + x^2}$. This force will be a maximum when $\frac{dF}{dx} = 0$, that is, when

$$\frac{1}{l^3} - \frac{3x^2}{l^5} = 0,$$

which occurs when $x = \frac{r}{\sqrt{2}}$; $\tan\theta = \sqrt{2}$; $\theta = 54° 44'$ Hence a series of co-axial rings will be most advantageously disposed

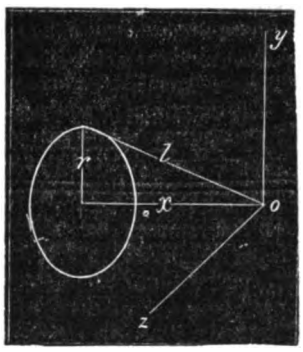

FIG. 68.

for producing force at a point on the axis if they lie on a cone having its vertex at the point in question, with a semi-vertical angle of 54° 44'.

The greatest force will be produced when the pole-pieces are themselves saturated, so that I reaches its limiting value in all parts of the metal. In that case the distribution of density from ring to ring is uniform. The surface density of free magnetism at any point of a sloping pole-face is $I \sin\theta$, where θ is the slope of the face to the axis of magnetisation. The whole quantity in each ring is I multiplied by the area of the ring projected upon a plane normal to the axis—a quantity which is independent of the slope of the cone. We have, therefore, the same series of attracting rings to deal with, whatever be the slope of the convergent faces, and whether that slope be uniform or not. Given, then, a certain diameter

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† Ewing and Low, *Phil. Trans.* vol. 180, 1889, A, p. 221; *Rep.* Brit. Assoc., 1887, p. 586.

* Parts of this and the succeeding paragraphs are taken from the Paper cited (*Phil. Trans.* 1889, A, p. 221).

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for the neck of the bobbin to be magnetised, the greatest magnetic force will be produced at the middle of the axis of the neck, when the pole-pieces are saturated and when we make the expanding ends and pole-faces in the form of cones, with a semi-angle of 54° 44′, and with their vertices at the middle of the neck.

This determines what may be called the cones of maximum concentrative power. In practice cones intended to produce as great a concentration as possible should have a somewhat greater semi-angle—say 60° or so—because of the defective saturation of the pole-pieces.

§ 96. Greatest Magnetising Force producible by Means of Cones.—With a cone of any semi-angle θ, magnetised to a uniform intensity I_0, the surface density of free magnetism is $I_0 \sin\theta$, and the force at the vertex due to a ring at an axial distance x, of radius r, and of length dl, measured along the slope, is

$$2\pi r\,dl.\,I_0 \sin\theta.\frac{x}{l^2}, \text{ or } 2\pi I_0 \sin^2\theta\cos\theta\frac{dr}{r}.$$

The whole force at the vertex is

$$2\pi \sin^2\theta\cos\theta\int_a^b \frac{I_0\,dr}{r},$$

a being the radius of the neck on which the cone converges, and b the radius of the base to which it spreads.

Hence (treating I_0 as uniform), with a pair of truncated cones, joined by a neck at the middle of which they have their common vertex, the whole force there is

$$F = 4\pi I_0 \sin^2\theta\cos\theta\log_\epsilon\frac{b}{a},$$

which, for convenience of calculation, may be written

$$F = 28{\cdot}935\, I_0 \sin^2\theta\cos\theta\log_{10}\frac{b}{a}.$$

Applying this to the cones of maximum concentrative power (§ 95), in which $\sin\theta = \sqrt{\frac{2}{3}}$ and $\cos\theta = \sqrt{\frac{1}{3}}$.

$$F_{max.} = 11{\cdot}137\, I_0 \log_{10}\frac{b}{a},$$

and the greatest value of the force will be obtained when I_0 has the saturation value (of say 1,700 C.-G.-S. units for soft wrought iron), in which case

$$F_{max.} = 18930\,\log_{10}\frac{b}{a},$$

an expression which measures the greatest possible force which the isthmus method of magnetisation can apply at a point in the axis of the bobbin (over and above the small force which is directly produced by the magnet coils). It is not practicable to produce quite so large a force, because the magnet poles cannot be fully saturated.

§ 97. Form of Cone to give most Uniform Field.—The cone of maximum concentrative power is not the form best suited for producing a uniform magnetic force throughout the neck. It makes the field rather stronger at places near the axis than on the axis itself. To make the field as nearly uniform as possible in and close to the neck we must slope the cone at such an angle that $\frac{d^2F}{dx^2} = 0$, a condition which secures that $\frac{d^2F}{dy^2}$ and $\frac{d^2F}{dz^2}$ shall also be zero. This condition is satisfied when

$$\frac{9x}{l^5} - \frac{15\,x^3}{l^7} = 0,$$

which makes $x = r\sqrt{\frac{3}{2}}$; $\tan\theta = \sqrt{\frac{2}{3}}$; $\theta = 39° 14'$.

In other words, the best approximation to a uniform field (the pole-pieces being saturated) is reached when the pole-faces are cones converging upon the middle of the neck, with a semi-vertical angle of 39° 14′. When the cones have this form, and he neck is very narrow in comparison with the base, the field is so nearly uniform that the magnetic force in a narrow ring of space close to the neck may be taken to represent, without sensible error, the force within the neck itself, and there is no practical variation of the force in the neck from end to end, or from side to centre.

With cones of this form the concentration of force upon the neck is less than in the former case. Using the same notation as before the force is

$$15{,}240\,\log_{10}\frac{b}{a},$$

in the event of the poles being of wrought iron and fully saturated.

The difference between the two cases is illustrated by Figs. 69 and 70, where curves are drawn to show the force exerted at

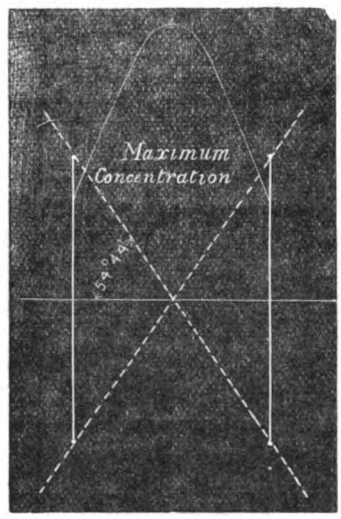

FIG. 69.

various points on the axis by a single pair of rings, forming parts of conical pole-faces which have a common vertex. In Fig. 69 the rings are parts of cones of maximum concentration; in Fig. 70 they are parts of cones shaped to produce the best

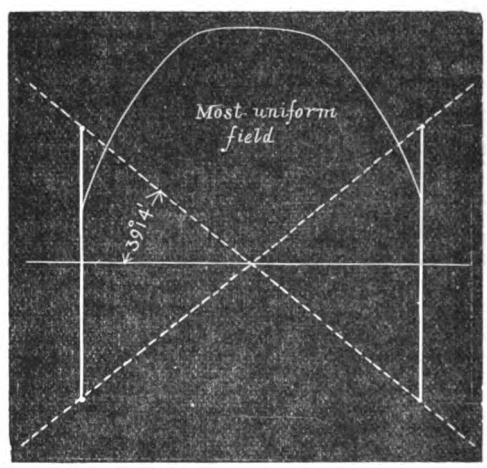

FIG. 70.

possible approximation to a uniform field. The rings are taken equal in both cases, so that the height to which the curves rise in the middle will serve for comparison of the forces; the flatness of the curve in Fig. 69 shows the superiority of that form of cone in respect to uniformity of field. With actual conical pole-pieces, the force produced in the neck is, of course, made up of the sum of the forces due to pairs of rings like these distributed over the whole conical surface.

(To be continued.)

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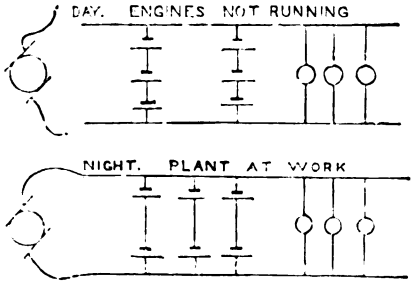
THE LIGHTING OF LONDON THEATRES BY ELECTRICITY.

BY ED. C. DE SEGUNDO, A.M.I.C.E.

From the comprehensive nature of this title the reader might be led to expect a more complete account of this subject than is contained in the following lines. I must, therefore, commence with an apology for leaving entirely out of account the historical side of the question, inasmuch as to do justice to this subject from an historical point of view would entail the double disadvantage of taking up a considerable amount of space, and of giving rise to possible distinctions as to whom honour is due as the pioneer of electric lighting in theatres in London and so forth. I need, for similar reasons, offer no further apology for not introducing any remarks of a critical nature, this article being intended to be purely of a descriptive character.

The majority of theatres in London which are lighted by electricity are supplied by suitable plant erected on the premises; and as only those installations which possess some features of novelty need be described, I propose to enter briefly into the details of the plant erected at the Lyric Theatre, Mr. D'Oyly Carte's new theatre, the Court Theatre, and Covent Garden Theatre; and to append a table giving the types of installations in use at, or the manner in which electrical energy is supplied to, the chief theatres now lighted by electricity in London.

Through the kindness of Messrs. J. B. Verity and Sons, of King-street, Covent-garden, I have had an opportunity of examining the plans of the installation now being erected to supply Mr. D'Oyly Carte's new theatre. The plant consists of three Marshall boilers of the locomotive under-flue type, 16ft. long, supplying steam at 140 pounds per square inch to three



Willans double-tandem compound high-speed engines, each coupled direct to a Siemens dynamo, capable of giving 650 amperes at 110 volts. The boilers are fed by a duplicate set of two cylinder steam force pumps, arranged to draw either from a feed water-heater through which a portion of the exhaust from the engine passes, or to supply direct from a tank filled by the water main. Two other heaters, also operated by the exhaust from the engines, supply the hot water for heating the building. In regard to this latter question, it is intended to supplement the heating of the auditorium by means of a fan which will draw air from the room in which the resistances are placed and discharging into the house, while a 2½ horse-power motor will actuate a fan in the dome for ventilating purposes.

The engines are each of 135 horse-power, and the steam from the boilers passes first through a separator placed by the side of the engine, to which is attached a water gauge and trap whereby any accumulation of water is expelled. Enough storage plant in the shape of two sets of 31-L.E.P.S. cells, each consisting of 55 in series, is provided for all day work, such as rehearsals, cleaning, &c.; and a special feature in the arrangement is an ingeniously devised switch, by means of one turn of which the two sets are coupled up in three sets in parallel with the lamp circuit during the run at night, thus acting as equalisers and also receiving a charge for the next day's work, the changes being diagrammatically represented above :—

In regard to the installation in the theatre the following points may be mentioned. The switchboard is at some elevation from the stage, so that the operator in no way interferes with stage work, and the various apparatus are out of reach of an accidental injury. The necessary resistances are collected in a room below the stage, and are in the form of straight runs of platinoid wire, about 100 feet being allowed for every 60 amperes of current, the electromotive force being reducible from 100 to 50 volts. These resistances are operated from the switchboard gallery by means of cords. Unfortunately, the theatre is not in a sufficiently advanced state to enable any judgment of the internal fittings to be made; but these, there can be no doubt, will be of the newest and most tasteful design, as no expense is being spared to ensure the complete success of the lighting arrangements. Messrs. Verity and Sons are introducing some new points in battens; but these are not yet sufficiently worked out, and any publication of such details would naturally be premature.

The Lyric Theatre.—This installation is, I believe, originally due to M. Sechehaye, a Swiss engineer, and is certainly a most complete installation for theatrical purposes. Mr. Henry Lyon, who has been in charge from almost the time the theatre opened, has kept a most complete and detailed record of the performance of the plant day by day, and has been good enough to put me in possession of very complete details not only of technical but of commercial matters. The importance of the commercial side of the question is, of course, great, and the value of the figures given me by Mr. Henry Lyon is manifest, inasmuch as they are taken from accounts actually paid. Before quoting these figures a description of the plant would be interesting, as it constitutes a unique system of generation and distribution.

The power is supplied by two 16 horse-power nominal Stockport gas engines, each working up to about 23 brake horse-power, and each belted to a Statter dynamo. The engines, though somewhat wasteful in gas consumption (32 cubic feet per indicated horse-power per hour) have given great satisfaction. Mr. Lyon reports no serious break-down, although they run from 18 to 20 hours a-day regularly. The dynamos are coupled either singly or in parallel to one or more sets of cells as occasion may require. The battery plant consists of 424 31-L. E.P.S. cells arranged in eight parallels of 53 in series. The charge and discharge are controlled by a very complete and conveniently-arranged switchboard, the large lever-switch controlling the end cells of each battery being designed to avoid the sparking that would ensue in switching a parallel of end cells in or out of charge or discharge, by short-circuiting the cells, as the switch passes from one contact block to the other, through a resistance. The whole of the lights in the house are arranged on 13 main circuits, each controlled by a single pole brush switch on the lead and return. The various circuits are so arranged as to admit of the most complete and easy control of the lighting of the theatre under the various circumstances. The stage switchboard is placed at some elevation from the stage, the operator being thus perfectly free and unmolested—an advantage both for the management and for the operator.

The arrangements on the stage are of the most complete nature. I do not remember any theatre I have seen in which the light from the battens can be varied both in intensity and in colour to so great an extent and with such ease. No limelights are used, the necessary effects being produced by portable arc lamps. Mr. Lyon gave a practical demonstration of the above assertions, and kindly went into the detail of his novel system of liquid resistance, which he has protected, and which by a very simple device reduces to a minimum the noise of the explosion of the collected gas on the plates ignited by the inevitable spark when the lamps are finally extinguished. It is perhaps worthy of mention that there is not a single gas-jet anywhere on or near the stage; and the 21 months' run without any breakdown serious enough to cause an extinction or even a diminution of the intensity of the lights, from 424 storage cells charged by gas-engine power, reflects great credit on Mr. Lyon's system of supervision and arrangement. I may just mention, without comment, that this installation, as designed by M. Sechehaye, cost £19,000.

(To be continued.)

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THE LONDON AND PARIS TELEPHONE CABLE.

Telephonic communication between London and Paris is now merely awaiting the consent of the French Government. Mr. Preece stated at the Newcastle meeting of the British Association that experiments had been made to ascertain under what circumstances such communication was possible; and in February, 1887, he communicated to the Royal Society a Paper in which it was stated that, taking the resistance of a conductor in ohms, and its capacity in microfarads, telephonic communication is good, when the product of these is 5,000; when it is 10,000 talking is just possible, and the limit is reached at 15,000, when no articulation is audible. Experiments have been made with telephones on the cables between Dover and Calais, between Holyhead and Dublin, between South Wales and Wexford; and from the results of these, the officials of the Post Office are perfectly satisfied that they can build a line between the capitals of the two countries through which telephonic communication will be not only possible, but highly satisfactory.

The present cable between Dover and Calais is quite unsuitable for the purpose, both on account of its high resistance and its capacity. The requisite details of the new cable and the land lines have been worked out, and the results of the calculations have been compared with the tests recently made upon a line from Baldock in Hertfordshire, through London to Worcester. In this experiment, which was conducted with the view of determining the constants of the proposed line to Paris, two copper wires were employed, and no less than 27 miles of the circuit was through the underground system of the postal telegraphs in London. The communication through this line by telephone was very good, and confirmed in a very satisfactory manner the calculations which have been made. The telegraphic communication between London and Paris has increased very considerably during the past few years; and as it is necessary to make some extensions, it has been considered that the new line should be one through which telephony could be carried on.

The land line will consist of four copper wires, and M. Jules Roche has asked the Chamber of Deputies for a grant of £16,000. A Bill has been introduced to create a supplementary credit for this amount at the Ministry of Commerce. This represents the share of the French Government in the cost. A further outlay of £12,000 will probably be required. The route of the new cable will be between Sangatte, near Calais, and Folkestone.

As soon as the Bill has passed the Chamber operations will be commenced; and, as the French Government are fully alive both to the importance and to the practicability of the matter, it is not likely that any obstacles will arise, and it may be expected that the line will be ready before the end of the year.

THE WORKING EFFICIENCY OF SECONDARY CELLS.*

By W. E. Ayrton, C. G. Lamb, E. W. Smith, and M. W. Woods, Associates.

(Continued from page 321.)

We therefore adjusted the automatic interruptor to stop the discharge when the potential difference per cell was 1·8 volts, and the immediate result of this was to bring the time of charging up to 12½ hours, and to bring up the time of discharging to 10½ hours. After continuing the charging and discharging continuously day and night for 13 days, the cells reached a perfectly steady state. Curve 8 shows the time curve of potential difference per cell in the discharges finished in the early morning of June 19th, recommenced in the night of June 19th, and again commenced late on June 20th, all the three discharges being so precisely similar that they can be represented by one curve; and, similarly, curve 9 shows the intermediate charging curves on June 18th, 19th, and 20th, which were also exactly the same. The times of the three discharges and of the three charges were, respectively, in hours and minutes—

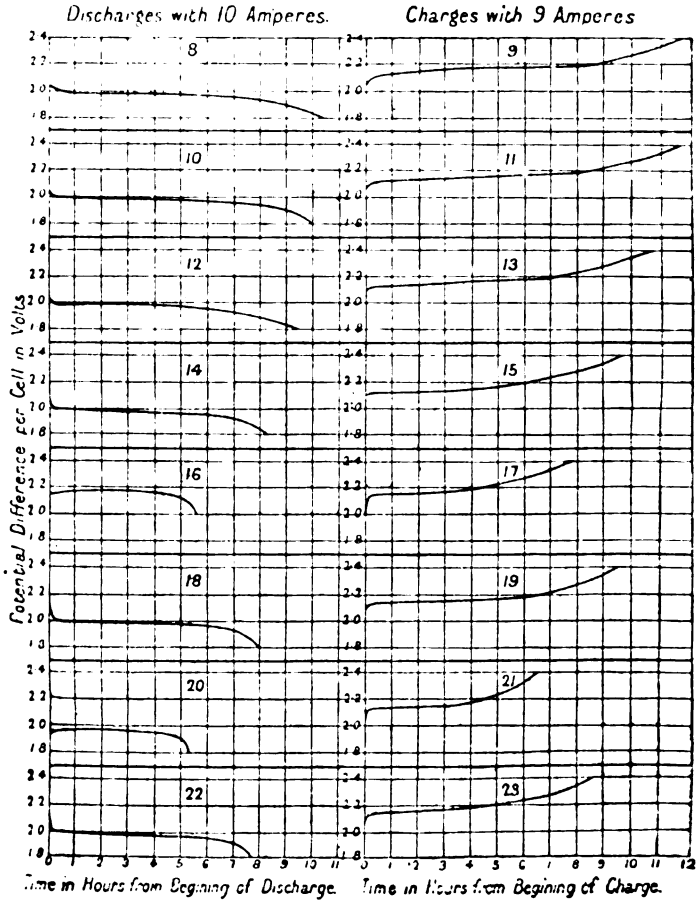
Times of Successive	
Discharges.	Charges.
10 h. 10 m.	11 h. 38 m.
10 h. 10 m.	11 h. 37 m.
10 h. 11 m.	11 h. 37 m.

showing to what an absolutely definite state cells arrive after a definite cycle of charge and discharge between fixed limits has been repeated continuously without interruption for some weeks.

Integrating these curves, we find—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell	Quantity.	Energy.
101·9	201·7	104·5	230·7	97·2	87·4

The numbers contained in this last table may probably be considered as giving the steady working values for this size and type of cell. 230·7 watt-hours are equivalent to 612,200 foot-lbs., and as the positive and negative plates of one cell weigh 28lb. 10oz., the *working* storage capacity is 21,380 foot-lbs. per lb. of plate.


Discharges with 10 Amperes.
Charges with 9 Amperes
Potential Difference per Cell in Volts
Time in Hours from Beginning of Discharge.
Time in Hours from Beginning of Charge.

VII.—*Effect of Rest.*

We next tried the effect produced on the capacity and efficiency of accumulators by prolonged rests. The five cells used in the experiments stood on porcelain insulators containing resin-oil; and as the insulators, which were specially made for the Central Institution, were taller than those commonly employed to support accumulators, and as all connecting wires were removed from the cells while they were allowed to rest, it is certain that any change in the cells must have been caused by internal action, and could not have been due to external leakage.

The cells, having been fully charged on June 22nd, were allowed to rest, insulated as above described, until July 2nd—that is, for 10 days. The first few curves of discharge and charge after the rest showed a considerable diminution in the capacity and efficiency; but after one week's continuous charging day and night, a steady cycle was reached, the following being the times of successive dis-

* Read at the Extraordinary General Meeting of the Institution of Electrical Engineers at Edinburgh, on July 16th, 1890.

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charges and charges, the limiting potential differences, as before, being 1·8 and 2·4 volts :—

TIMES OF SUCCESSIVE

Discharges.	Charges.
10 h. 1 m.	11 h. 35 m.
9 h. 59 m.	11 h. 30 m.
9 h. 58 m.	11 h. 32 m.
9 h. 57 m.	11 h. 33 m.

Curves 10 and 11 show the variation of the potential difference per cell ; and on integrating these curves we obtain :—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
100	198	103·8	228·2	96·4	85·8

Rest, then, of an accumulator, although left well insulated and fully charged at the commencement, alters the accumulator so that for the first few charges and discharges after the rest it is a much less valuable instrument than before. A week's continuous charging and discharging day and night, however, removes this effect to a great extent ; the efficiency, however, still remains somewhat lower than before the rest.

Next, the cells were allowed to rest charged for 12 days, until August 1st. The first discharge at the end of the rest gave a quantity efficiency of only 80 per cent., so that 20 per cent. of the charge was lost. After a week's continued charging and discharging between the former limits of volts, the cells regained a steady state, but the time of charge and of discharge is now less than before this second rest. The times after the week's charging and discharging were :—

TIMES OF SUCCESSIVE

Discharges.	Charges.
9 h. 3 m.	10 h. 41 m.
9 h. 2 m.	10 h. 44 m.
9 h. 10 m.	10 h. 51 m.

Curves 12 and 13 show the potential difference curves when the cells had acquired a steady state, and on integrating them we find :—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
91	176·7	96·8	213·2	94·1	82·8

We see, then, that a week's continuous charging and discharging of these cells is unable to compensate for the harm produced by their being left for 12 days fully charged. The two rests of 10 days and 12 days respectively, although followed in each case by a week's continuous charging and discharging, have reduced the discharge ampere-hours by 10 per cent., the discharge watt-hours by 12 per cent., the quantity efficiency by 3 per cent., and the energy efficiency by 5 per cent.

Third Rest.—The cells having been fully charged, a third rest of 16 days took place. On the first discharge, at the normal rate of 10 amperes, the ampere-hours were only 75. After, however, the charging and discharging at the normal rates had been continued for three days and nights, the times of discharging and charging became steady.

TIMES OF SUCCESSIVE

Discharges.	Charges.
8 h. 12 m.	9 h. 28 m.
8 h. 17 m.	9 h. 35 m.
8 h. 19 m.	9 h. 35 m.

and curves 14 and 15 show the working values of the potential difference in discharging and charging. Integrating the curves, we obtain :—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
82·6	161·3	86·2	190·5	95·8	84·7

Fourth Rest.—The cells, having been fully charged, were allowed to rest for 16 days. Curve 16 gives the values of potential difference obtained at the *first discharge*, and curve 17 the values of the potential difference obtained immediately afterwards in charging. Integrating the former curve, and comparing its area with the area of the charge curve 15 obtained just before the rest, we find :—

First discharge after rest.		Last charge before rest.		Percentage efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
56·5	110·5	86·2	190·5	65·5	58

If, however, we compare the result of the first discharge after the rest with the first subsequent charge, shown in curve 17, we find :—

First discharge after rest.		First charge after rest.		Percentage efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
56·5	110·5	71·1	158·3	79·6	69·6

The cells were now continuously, without intermission, charged with the normal current of 9 amperes, and discharged with 10 ; the discharge, as before, being automatically stopped when the potential difference per cell had fallen to 1·8 volts, and the charge when it had risen to 2·4 volts. The following give the successive times in hours and minutes in which the cycles were completed :—

First discharge after rest,			5h. 40m.	First charge,	7h. 54m.
Second	„	„	7h. 6m.	Second „	8h. 30m.
Third	„	„	7h. 31m.	Third „	8h. 51m.
Fourth	„	„	7h. 29m.	Fourth „	8h. 52m.
Fifth	„	„	7h. 43m.	Fifth „	9h. 17m.
Sixth	„	„	8h. 0m.	Sixth „	9h. 24m.
Seventh	„	„	8h. 5m.	Seventh „	9h. 17m.
Eighth	„	„	7h. 57m.	Eighth „	9h. 20m.

From the last three discharges and charges we see that the cells have arrived at a steady state, and curves 18 and 19 show the steady, or working values of the potential difference for these three discharges and charges. Integrating the areas of these two sets of curves, we find :—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
80	156·9	83·8	184·6	95·5	85

Fifth Rest.—The cells were now left charged for a further period of 16 days. Curve 20 gives the values of the potential difference obtained at the first discharge after the rest, and curve 21 the values of the potential difference obtained immediately afterwards in charging. Integrating the areas of these curves, we have :—

First discharge after rest.		Last charge before rest.		Percentage efficiency.	
Ampere-hours.	Watt-hours per cent.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
53·3	104·1	83·8	184·6	63·6	56·4
		First charge after rest.			
		58·5	128·3	91·1	81·1

Continuous charging and discharging with the normal currents between the normal limits of potential difference per cell gave the following times for completing the cycles :—

First discharge after rest,			5h. 20m.	First charge,	6h. 30m.
Second	„	„	6h. 18m.	Second „	7h. 29m.
Third	„	„	6h. 42m.	Third „	7h. 59m.
Fourth	„	„	6h. 54m.	Fourth „	8h. 19m.
Fifth	„	„	7h. 15m.	Fifth „	8h. 20m.
Sixth	„	„	7h. 16m.	Sixth „	8h. 30m.
Seventh	„	„	7h. 23m.	Seventh „	8h. 41m.
Eighth	„	„	7h. 34m.	Eighth „	8h. 44m.
Ninth		„	7h. 40m.	Ninth „	8h. 47m.

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Discharge.				Charge.				Percentage Efficiency.	
Duration of discharge.	Ampere-hours.	Watt-hours per cell.	Number of curve.	Duration of charge.	Ampere-hours.	Watt-hours per cell.	Number of curve.	Quantity.	Energy.
			Cells in normal state.						
h. m.				h. m.					
10 12	101·9	201·7	8	11 38	104·5	230·7	9	97·2	87·4
		Rest of 10 days.	Cells then charged and discharged many times until brought to a steady working state.						
10 0	100	196	10	11 31	103·8	228·2	11	96·4	85·8
		Rest of 12 days.	Cells then charged and discharged many times until brought to a steady working state.						
9 8	91	176·7	12	10 45	96·8	213·2	13	94·1	82·8
		Rest of 16 days.	Cells then charged and discharged several times until brought to a steady working state.						
8 24	82·6	161·3	14	9 36	86·2	190·5	15	95·8	84·7
			Rest of 16 days.	*First* discharge and charge after rest.				Ratio of first discharge *after* rest to last charge *before* rest.	
5 41	56·6	110·5	16	7 54	71·1	158·3	17	65·4	58·0
								Ratio of first discharge *after* rest to first charge *after* rest.	
								79·6	69·6
			Cells now charged and discharged several times until brought to a steady working state.						
8 0	80	156·9	18	9 20	83·8	184 6	19	95·5	85·0
			Rest of 16 days.	*First* discharge and charge after rest.				Ratio of first discharge *after* rest to last discharge *before* rest.	
5 21	53·3	104·1	20	6 30	58·5	128·3	21	63·6	56·4
								Ratio of first discharge *after* rest to first charge *after* rest.	
								91·1	81·1
			Cells now charged and discharged several times until brought to a steady working state.						
7 6	76	149·5	22	8 12	78 3	173·5	23	97·1	86·3

It was concluded from the times of the last three charges and discharges that the cells had acquired a steady state, and curves 22 and 23 show the time fall and the time rise of potential difference. Integrating the areas of these curves, we have :—

Discharge.		Charge.		Percentage working efficiency.	
Ampere-hours.	Watt-hours per cell.	Ampere-hours.	Watt-hours per cell.	Quantity.	Energy.
76	149·5	78·3	173·2	97·1	86·3

The above table gives a *resumé* of these results, all the discharges being made with 10 amperes until the potential difference cell to 1·8 volts per cell, and all the charges being made with 9 amperes until the potential difference per cell rose to 2·4 volts. Before each rest the cells were charged until the potential difference per cell was 2·4 volts.

From the preceding table it will be seen that, in spite of the continued charging and discharging at the end of each rest, there is a steady falling off in the quantity capacity from 101·9 ampere-hours at the beginning to 76 ampere-hours at the end, and in the energy capacity from 201·7 watt-hours to 149·5 watt-hours. The quantity and energy efficiencies, 97·1 and 86·3 per cent. respectively, at the end are the same as at the beginning. Comparing the first discharge after each of the 16 days' rest with the last charge before the rest, there appears to be a loss of about 36 per cent. in the ampere-hours, and about 43 per cent. in the watt-hours ; or, since the normal quantity and energy efficiencies for a discharge immediately following a charge are respectively 97 and 87 per cent., it follows that the rest of 16 days causes a loss of about 33 per cent. in the ampere-hours, and about 30 per cent. in the watt-hours, in addition to the losses that normally occur on a charging immediately followed by a discharging.

From all that precedes, it follows that the previous history of an accumulator produces an enormous effect on its efficiency. If, for example, an E.P.S. accumulator be over and over again carried round the cycle of being charged up to 2·4 volts per cell, and discharged down to 1·8 volts per cell, the charging and discharging currents being the maximum allowed by the makers—viz., 0·026 ampere per square inch in charging, and 0·029 ampere per square inch in discharging—the "*working efficiency*" thus obtained may be 97 per cent. for the ampere-hours and 87 per cent. for the watt-hours. If, on the contrary, the cell be constantly charged up before being tested, then, for the first few charges and discharges between the above limits, and with the same current density in charging and discharging, even the *energy* efficiency may be as high as 93 per cent. ; whereas, if the accumulator has been left for some weeks, then, although it was left charged, the energy efficiency for the first few charges and discharges will be as low as 70 per cent.

While, on the one hand, our tests show that continued rests of a charged accumulator appear to be far more serious for the accumulator than we had previously imagined, the working efficiency appears to be higher than has hitherto been supposed, since we believe that about 84 per cent. efficiency in the watt-hours is all that the advocates of accumulators have claimed for them.

The smallness of the first discharge after a rest might be due either to a kind of electric short-circuiting and dissipation of the energy, or to some change in the character of the active material converting the energy perhaps directly into heat, or to some of the active material having become disconnected from the plates during the rest and having fallen down to the bottom of the cell. The smallness of the first *charge* subsequently to the first discharge after the rest, shows that mere electrical leakage during that time has not been the cause of the loss of energy, while the steady increase in the storage capacity brought about by a series of charges and discharges tends to show that rest brings about some change in the nature of the active material.

In all the tests in which the results are given in the preceding table, the charge and discharge were, as already stated, terminated when the potential difference per cell reached a fixed value ; it is, therefore, possible that the apparent falling off in the capacity of the cells to store energy may be due to a change in the resistance of the cells produced by the rest. For a change in the resistance of the cells will change the terminal potential difference for a given current flowing through the cells without there being any necessary change in the storage capacity.

It is, therefore, interesting to study the variations in the shapes of the potential difference curves 8 to 23. First, as regards the charge curves, 9 and 11 are convex everywhere to the axis of time except just when the charging is commenced ; whereas 13, the steady working charge curve after the second rest, rises much more rapidly when the potential difference cell is about 2·3 volts than is the case in the other two curves, then bends over and becomes concave to the axis of time. This peculiarity in curve 13 is, we notice, not very striking in the small reproduction of this curve in the text, but in the original curves as plotted on large sheets of squared paper from the results of the tests, the difference between curves 11 and 13 is very noticeable.

The following list gives the time in hours and minutes from the commencement of the charging when the potential difference per cell reaches 2·2 volts :—

Curve 9 ... 7h. 14m. .. Steady working charge before rest.
„ 11 ... 7h. 32m. ... „ „ „ after first rest.
„ 13 ... 7h. 10m. ... „ „ „ „ second rest.
„ 15 ... 5h. 36m. ... „ „ „ „ third rest.
„ 17 ... 3h. 54m. ... First charge after fourth rest.
„ 19 ... 5h. 43m. ... Steady working charge after fourth rest.
„ 21 ... 4h. 50m. ... First charge after fifth rest.
„ 23 ... 4h. 40m. ... Steady working charge after fifth rest.

It is clear, then, that the effect of a series of rests is to cause the potential difference to rise much more rapidly in subsequent charges, and the time curve rise of potential difference still remains unusually steep, although at the end of every rest there was a prolonged and uninterrupted series of charges and discharges.

Curves 16 and 20, which gives the values of the potential difference for the *first* discharges after the fourth and fifth rest, show that for the first hour from the beginning of each of these discharges

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the potential difference *rises instead of falling*, as is the case in normal discharges.

If the rapid fall of potential difference at the commencement of a discharge be due to a disappearance of gases occluded in the plates, as some have supposed,—or if, as Dr. Gladstone and Mr. W. Hibbert imagine, the charging of a cell causes the acid round the positive plate to become denser than that round the negative, and the mixing of the denser and less dense acid at the commencement of the discharge causes the potential difference to fall,—then the absence of this fall at the beginning of a discharge after a long rest would be explained; but neither of these theories would apparently explain the rise of the potential difference obtained by us at the commencement of a discharge after a long rest. Indeed, the fact that it required two discharges and two charges after a long rest before the discharge curve (the third after the rest) acquired its normal form, tends to show that this rise of potential difference at the commencement of the first discharge after a long rest is due to some other cause.

Again, Prof. Duncan and Mr. H. Wiegand have shown in their communication that the diffusivity of the sulphuric acid into the plugs is greatest at the end of the charge, and least at the end of the discharge. Hence, if it be the diffusing out of the strong sulphuric acid from the plugs of the positive plate that causes the rapid fall of E.M.F. on breaking the charging circuit at the end of a charge (see Figs. 3, 4*, and 11†), one would hardly expect that it would be at the *end* of a discharge, when the diffusivity of the acid in the plugs was a minimum, that the rise of E.M.F. on breaking the discharging circuit would be most rapid, but that numerous experiments have shown us to be the case. In fact, curve No. 8, Fig. 11†, shows that towards the end of the charge the E.M.F. falls from 2·298 to 2·274 volts in 20 seconds after breaking the charging circuit, and similar curves that we have drawn from our experiments on the time rise of E.M.F. on breaking the discharging circuit show that towards the end of the discharge the E.M.F. rises from 1·951 to 1·970 volts in 20 seconds, the latter rate of rise being almost exactly equal to the former rate of fall.

All the rests already referred to occurred when the cells were fully charged; but before these long rests took place the cells, when in their formal state, were on one occasion allowed to remain discharged for 34 minutes, with the following result:—

Cells in Normal State.

Time taken to complete—

Charging 11h. 38m.
Discharging 10h. 10m.
Next „ 11h. 37m.
Next „ 10h. 12m.
Next „ 11h. 37m.
Next „ 10h. 11m.

Cells here remained discharged for 34 minutes.

First charging after rest, 11h. 50m.
First discharging after rest, 10h. 15m.
Next charging after rest, 11h. 42m.

These results emphasise the fact that accumulators are damaged if left discharged, even for a short time; and it was for this reason that during the whole of this investigation the cells were never left discharged for a longer time than was necessary to change over the connections from discharge to charge, except on this one occasion, when it was desired to ascertain the magnitude of the change produced by leaving the cells discharged for a short time.

It is interesting to notice that the effect of discharging cells too low, or of leaving them discharged, is to increase the times required for the subsequent chargings, whereas the effect of leaving them charged is to diminish the times required for the next chargings.

VIII.—*Chemical Action.*

Dr. Frankland has shown that probably the discharge of an ordinary accumulator is accompanied by the formation of one or other, or both, of the new lead salts which he has isolated, and which have the formulæ ($Pb_3S_2O_{10}$) and ($Pb_5S_3O_{14}$) respectively. And he concludes that, in view of the great difficulty of electrolytically splitting up the well-known white sulphate of lead ($PbSO_4$), this sulphate is not formed in the ordinary discharge of the accumulator, and is only produced when the cell begins "to sulphate."‡

Prof. W. Kohlrausch and C. Heim show in their Paper already referred to that the observed variations in the specific gravity of the liquid during charge and discharge agree well with the very simple chemical actions—

Charge.

Positive plate—
$$PbSO_4 + 2\,H_2O + SO_4 = PbO_2 + 2\,H_2SO_4.$$
Negative plate—
$$PbSO_4 + H_2 = Pb + H_2SO_4.$$

Discharge.

Positive plate—
$$PbO_2 + H_2SO_4 + H_2 = PbSO_4 + 2\,H_2O.$$
Negative plate—
$$Pb + SO_4 = PbSO_4.$$

It is to be noticed, however, that the falling off in the specific gravity during discharge is merely a test of the amount of H_2SO_4 that is converted into H_2O, and affords no criterion as to what sulphate of lead is formed by the SO_3 liberated.

During our investigation we observed the variation in the specific gravity of the liquid during about 100 charges and discharges, and the mean of this large number of the fairly consistent results that we obtained showed that, with the accumulators we were testing, the variation in density per ampere-hour was about 0·000·232. This result is probably right to within 5 per cent., for our hydrometer would read accurately to about 0·001, which is about 5 per cent. of 0·03, the total change in specific gravity observed during the discharge; and, therefore, as each result is correct to something like 5 per cent., the mean of a hundred results will certainly be correct to within 5 per cent.

On referring to tables of the density of dilute sulphuric acid, we find, by plotting the results, that between the limits we are concerned with—1·2 and 1·17—the change of density is directly proportional to the amount of SO_3 taken from the solution; and, further, that to produce a change in density of 0·01 at 15° C., it requires that 1 gramme of dilute sulphuric acid of density 1·2 should give up 0·01268 of a gramme of SO_3. And as the liquid in each cell weighed about 10,490 grammes when the cell was charged and the density 1·2, it follows that the weight of SO_3 liberated per ampere-hour in each cell, when calculated from the variation in the specific gravity, must equal—

$$\frac{0{\cdot}000232}{0{\cdot}01} \times 0{\cdot}01268 \times 10{,}490 \textit{ grammes},$$

or

3·086 grammes.

Further, the electro-chemical equivalent of SO_3 is 0·000414 grammes per coulomb; and since lead sulphate is formed on both the positive and negative plates during the discharge, the weight of SO_3, taken out of the liquid per ampere-hour, when calculated from the electro-chemical equivalent of SO_3, must be

$$2 \times 3{,}600 \times 0{\cdot}000414 = \textit{3·041 grammes}.$$

These two results show a close agreement. At the same time, it is to be noticed that not merely does the amount of SO_3 liberated per ampere-hour come out somewhat higher when calculated from the *mean* change in the specific gravity than when calculated from the chemical equivalent, but the same result is obtained for each separate set of tests.

Mr. G. H. Robertson, working in Dr. Armstrong's laboratory, was so good as to analyse the sediment that fell to the bottom of the cells during the early part of the investigation, when in the discharges the potential difference was allowed to fall to 1·6 volts per cell. The mixture was found to contain—

An indication of uncombined metallic lead,
A trace of antimony,
40·95 per cent. of combined lead } *i.e.*, 47·3 per cent. of PbO_2
6·35 „ „ oxygen }
34·63 „ „ lead } *i.e.*, 50·74 „ „ $PbSO_4$
5·36 „ „ sulphur }
10·75 „ „ oxygen }
98·04

so that 1·96 per cent. consisted of metallic lead, antimony, and dirt.

The composition of the sediment showed a close approximation to PbO_2, $PbSO_4$, which consists of—

44·08 per cent. of PbO_2
55·92 „ „ $PbSO_4$

PbO_2, $PbSO_4$, in fact, contains—

76·33 per cent. of Pb
5·91 „ „ S
17·76 „ „ O

and the sediment contained—

75·58 per cent. of Pb
5·37 „ „ S
18·05 „ „ O

Dr. Frankland's salts may be represented as $PbO_2\,2(PbSO_4)$ and $2(PbO)\,3(PbSO_4)$ respectively, whereas the analysis of the deposit in our cells showed that it was certainly neither of these lead salts, but, instead, had almost the exact composition of PbO_2, $PbSO_4$.

In spite of accumulators with pasted plates having been in use now for nine years, the chemical action that takes place during the different stages of the charge and discharge has only been conjectured, and, odd as it seems, no decisive experiment appears to have been made to settle this much-debated question. Various analyses have been made by different chemists of salts of lead acted on in certain ways with sulphuric acid, but apparently not of actual accumulator plates in action. We are therefore now, with the assistance of Mr. Robertson, making a complete investigation of

* *Electrician*, July 18th, pp. 289 and 290.
† These figures will be given in due course.
‡ "Contributions to the Chemistry of Storage Cells," *Proc.* Roy. Soc., Vol. XLVI., 1889, p. 304.

Date.	Time.	Cell under test.		Temperature of		Time from beginning of discharge or charge.	Difference between temperature of cell under test and temperature of idle cell.	Rise or fall of temperature during a complete discharge or charge, compared with temperature of idle cell.
		State.	Temp.	Air.	Idle cell.			
1889.	Hrs. Min.		Degrees C.	Degrees C.	Degrees C.	Hrs. Min.	Degrees C.	
July 10th	1 10	Charged	19·95	18·75	18·6	0 0	1·35	
„	11 20	Discharged	18·6	18·6	18·5	10 10	0·1	− 1·25 during discharge.
„	16 55	Charging	19·6	19·1	18·81	5 35	0·76	
„	21 6	„	19·9	19·0	18·9	9 46	1·0	+ 1·2 „ charge.
„	22 50	Charged	20·2	18·8	18·9	11 30	1·3	
July 11th	7 55	Discharging	18·65	18·25	18·1	9 5	0·55	
„	8 50	Discharged	18·8	18·5	18·2	10 0	0·6	− 0·70 „ discharge.
„	11 38	Charging	19·05	18·6	18·4	2 48	0·65	
„	15 10	„	19·3	18·3	18·5	6 20	0·8	
„	19 50	„	19·7	19·0	18·7	11 0	1·0	+ 0·77 „ charge.
„	20 25	Charged	20·1	19·0	18·73	11 35	1·37	
„	21 42	Discharging	19·95	18·95	18·85	1 22	1·10	
July 12th	5 40	„	18·72	18·75	18·75	9 20	− 0·03	− 1·40 „ discharge.
„	6 20	Discharged	18·72	18·75	18·75	9 55	− 0·03	
„	7 50	Charging	19·3	18·65	18·7	1 30	0·6	
„	10 30	„	19·5	19·0	18·78	4 10	0·72	
„	12 40	„	19·61	19·1	18·77	6 20	0·84	+ 1·33 „ charge.
„	17 45	Charged	20·40	19·26	19·1	11 25	1·30	
„	21 30	Discharging	19·95	19·25	19·1	3 45	0·85	
July 13th	0 22	„	19·7	19·1	19·1	6 37	0·6	
„	2 55	„	19·73	19·2	19·16	9 10	0·57	− 0·67 „ discharge.
„	3 52	Discharged	...	...	...	10 7	...	
„	3 58	Just started charging	19·78	19·08	19·15	0 8	0·63	
„	10 20	Charging	20·0	19·2	19·15	6 28	0·85	
„	12 0	„	20·05	19·2	19·15	8 8	0·90	+ 0·77 „ charge.
„	14 20	„	20·30	19·25	19·2	10 28	1·1	
„	15 30	Charged	20·5	19·4	19·2	11 33	1·4	

the chemical state of the plugs of both the positive and negative plates at all stages of the charge and discharge of an 1888 E.P.S. type of accumulator in good condition. As this investigation, however, involves the chemical analysis of a large number of specimens, it will take some time yet to complete.

In order to observe what changes took place in the temperature of the cells during charge and discharge, the temperature of one of the cells under test was observed from time to time, as well as the temperature of the air and the temperature of an adjacent cell through which no current was being passed. The above temperature results, which were obtained during the steady discharges and charges after the first rest of ten days (curves 10 and 11), are a sample of the observations taken. The discharge in each case commenced directly the potential difference, in charging, had reached 2·4 volts per cell, and the charge in each case commenced directly the potential difference, in discharging, had fallen to 1·8 volts per cell.

From the preceding table we see that, while during the charge the cell rises in temperature, during discharge, on the contrary, it actually falls; hence, in spite of the production of heat due to resistance, the cell is actually cooler at the end of a discharge than at the beginning—a result possibly due to the splitting up of the sulphuric acid during the discharge. This cooling of accumulators during discharge, which we noticed early in our experiments, was also observed at about the same time by Prof. Duncan and H. Wiegand in America and described in their joint investigation already referred to.

From the last table we see that the rise of temperature of the cell during charging may, after allowing for changes of temperature of the room, be either about 1·3° C. or 0·77° C., while the fall of temperature during discharging may have either of the two preceding values. It is further interesting to notice that the rise of temperature during the charging has the higher or the lower of these two values according as the fall of temperature during the previous discharge had the higher or the lower value.

On plotting the differences between the temperatures of the working and the idle cell and the corresponding times given in the last table, we obtain the dotted line 24 (Fig. 8) for the time fall of temperature during the first and third discharge, curve 25 for the time rise of temperature during the first and third charge, curve 26 for the time fall of temperature during the second and fourth discharge, and curve 27 for the time rise of temperature during the second and fourth charges. 24 is dotted, since temperature readings were only taken at the beginning and end of the first and third of these discharges. In the case of the second and fourth of the discharges here referred to, as well as in all the four charges, several observations of temperature were made. From the curves it appears that towards the end of the discharge and at the beginning of the charge one or other of two things may happen—either the temperature in the discharge may go on falling, as in the dotted line 24, or it may begin to rise again, as in 26; whereas, in the charge, either the temperature at the beginning may rise considerably, as in curve 25, or it may only increase slightly, as in curve 27.

It would therefore appear that during the latter part of the discharge one or other of two chemical actions can take place; and these two actions have, for some reason or other, taken place alternately in the four discharges under consideration. But, curiously enough, these four discharges—which took place on July 10th, 11th, and 12th, 1889—occurred with extreme regularity; so that when time curves were drawn, even on a large scale, for each of these discharges, they coincided exactly and produced a single curve, which is shown, greatly reduced, as curve 10 on the sheet of curves given in the earlier part of the Paper. And, similarly, for the four corresponding charges the four time curves all coincided exactly, producing a single curve, which is shown, greatly reduced, as curve 11 on the same sheet. It, therefore, seems as if one or other of two chemical actions might take place during the latter portion of the discharge and during the earlier part of the charge, and yet, curiously enough, when the current is kept absolutely constant the time variation of the potential difference is exactly the same, no matter which of these two chemical actions takes place.

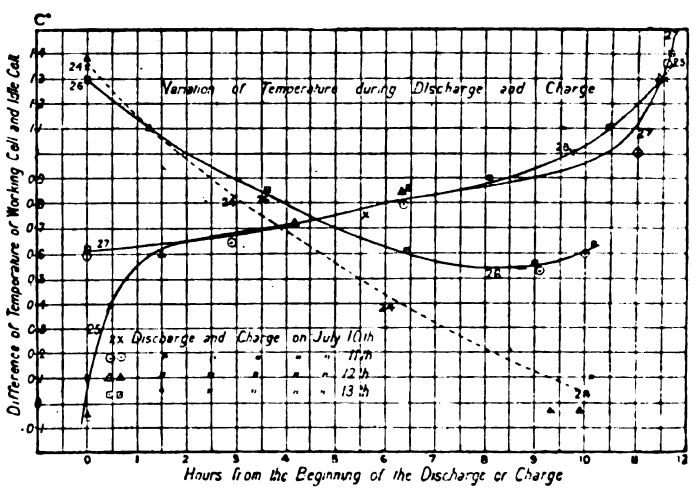
C°
Variation of Temperature during Discharge and Charge
Difference of Temperature of Working Cell and Idle Cell
Hours from the Beginning of the Discharge or Charge
xx Discharge and Charge on July 10th
" " 11th
" " 12th
" " 13th

Fig. 8.

About a year later another set of *continuous* temperature observations was made for many days and nights with the same cells, the current in discharging and charging being, as before, 10 and 9 amperes respectively. The higher potential difference limit was, as before, 2·4 volts per cell, but the discharge was in each case in this second set of continuous discharges and charges stopped at 1·9 instead of 1·8 volts per cell. As the regulation of the current day and night was in these later experiments in 1890 effected by hand, it was not kept quite as constant as when the automatic regulator was employed. Hence the time curves for the excess

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temperature in discharging and charging, when plotted, were not found to be as regular as in the previous case. But they were quite regular enough to give the general shape of the sets of temperature curves for discharge and charge which are shown in Fig. 9.

It will be observed that in these experiments not merely does the excess of the temperature of the working cell over that of the idle cell fall during the discharge, but it actually continues to fall at the commencement of the charge.

The times of discharging and charging are less than those given for curves 10 and 11, partly because the potential difference was not allowed to run down lower than 1·9 volts per cell in the later observations, and partly because the times of discharging and charging had been diminished by the continued experimental rests to which these cells had been subjected in a charged state during 1889.

The mean temperature of one of our cells is during charging and discharging, roughly, 0·7° C. higher than that of the air; and experiment shows that if one of the cells experimented on be warmed up by a portion of the ordinary dilute sulphuric acid being replaced by warm sulphuric acid of the normal density, the cell will, after all parts of it have acquired a uniform temperature, fall in temperature by 0·2443° C. per hour per 1° C. excess of temperature. Of course, during such an experiment no current is allowed to pass through the cell, nor should any current have passed for hours before the heat emissivity of a cell is determined, otherwise a wrong value of the emissivity may be obtained by local action in the cell generating or absorbing heat during the experiment.

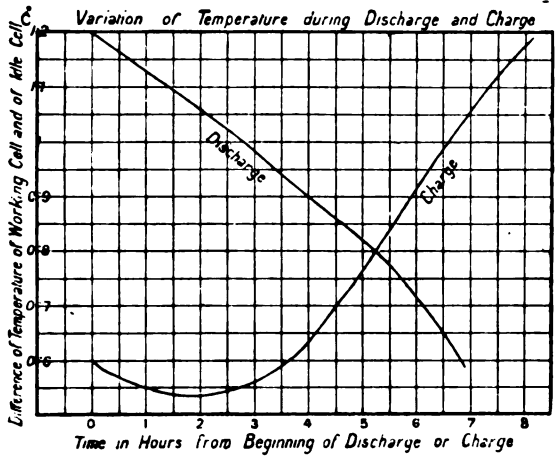
Variation of Temperature during Discharge and Charge
Difference of Temperature of Working Cell and of Idle Cell
Discharge
Charge
0 1 2 3 4 5 6 7 8
Time in Hours from Beginning of Discharge or Charge

FIG. 9.

Hence, if K be the heat capacity of the cell, $0·7 \times 0·2443 \times K \times 21\frac{1}{2}$ calories (gramme, Centigrade) will be lost by radiation and convection during the $21\frac{1}{2}$ hours of charging and discharging. Now the weights and specific heats of the component parts of one of the cells under test are—

	Weight in Grammes.		Specific Heat.
Dilute acid, sp. gr. 1·9	10,490	...	0·792
Lead and lead oxide ...	12,987	...	0 0315
Glass	3,402	...	0·198

Hence, 0·2443 K equals 2,295 calories, and the loss of heat in charging and discharging equals 34,520 calories. The total watt-hours given to a cell in charging was 228·2 (see Curve 11, for the *working* results obtained with the cells after the first rest of 10 days), therefore the energy in calories given to the cell was $0·24 \times 228·2 \times 3,600$, or 197,200 calories. Hence, in consequence of the cell being slightly warmer than the air during charging and discharging, there is a loss of energy from radiation and convection equal to about 17 per cent. of the energy put into the cell, and this is more than sufficient to explain the total loss observed in the energy efficiency experiments, which amounts to only about 13 per cent. Indeed, it would almost seem as if a portion of this heat radiated must be supplied by an actual slow consumption of the material of the cell; so that, in addition to the reversible oxidation and deoxidation of the material, which is the characteristic of the secondary cell, there was a certain amount of non-reversible oxidation, which is the characteristic of the primary cell.

The loss of energy in consequence of the current having to overcome the resistance of the cell is of far less importance than the loss of energy due to the actual continuous radiation and convection from the cell, which is slightly warmer than the air. For the mean resistance during discharge of one of the cells experimented on may be taken as 0 004 ohm (see Section IX., Resistance, Figs. 12 and 13), and the mean resistance in charging as 0·0045 ohm. Hence, during the normal 10 hours of discharge with 10 amperes there will be generated,

$$0·24 \times 10^2 \times 0·004 \times 10 \times 3,600, \text{ or } 3,456 \text{ calories,}$$

and during the normal $11\frac{1}{2}$ hours of charge with 9 amperes,

$$0·24 \times 9^2 \times 0·0045 \times 11\frac{1}{2} \times 3,600, \text{ or } 3,621 \text{ calories.}$$

Only, therefore, 3,456 calories need be dissipated during the discharge of a cell, and 3,621 during the charge, in consequence of the heat produced by the current overcoming resistance; and to dissipate this amount of heat it would only be necessary that the mean temperature of the cell should exceed that of the air by about 0·14° C., or only about one-fifth of the actual mean excess. Whereas what actually takes place is that during discharge about 16,060 calories are dissipated by radiation and convection; and, further, the cell cools down, possibly in consequence of the splitting up of the sulphuric acid, and from 6,000 calories in some experiments to 12,000 in others are thus absorbed. During the charge these 6,000 or 12,000 calories reappear warming up the cell, and, in addition, about 18,460 calories are dissipated by radiation and convection.

In order, then, to improve accumulators, what has to be especially sought for, and, if possible, then prevented, is that chemical action which keeps the mean temperature of the cell about 0·7° C. above that of the air. This chemical action is very possibly quite distinct from the reversible one which necessarily accompanies the storing up of the electric energy and its subsequent liberation.

(To be continued.)

THE CONTINUOUS-CURRENT TRANSFORMER AT THE CHELSEA COMPANY'S STATION AT DRAYCOTT-PLACE.

In the description of the above Company's station and sub-stations which appeared in *The Electrician* of May 30th last we mentioned the use which is to be made of continuous-current transformers, and also that one was already being arranged for testing. We are now able to give some particulars with reference to this machine. In appearance it resembles a two-pole inverted type Elwell-Parker dynamo. The armature is of the drum type, the two windings being upon the same core, and a commutator for each is arranged at opposite ends of the armature. The machine has been constructed by the Electric Construction Corporation (Limited), and has given very satisfactory results during the time it has been under test. The output for which the machine is intended is 33,500 watts, and the speed 1,000 revolutions per minute. There is obviously a necessity for extra precaution in insulating the high and low tension circuits from each other in the armature of the transformer on account of the mechanical stress.

The method adopted by the designers of the machine has been to wind up the primary into thin ebonite troughs, which are laid along on the surface of the armature. This has proved efficient so far. The insulation resistances, which have been steadily rising since the commencement of the tests, is at the time of writing as under:—

Between the windings .....17 megohms.
,, the thick wire and frame of machine..... 7·5 ,,
,, the thin wire and frame of machine..... 9 ,,

A test has recently been made of the performance of the transformer, the readings and the results of which are given in the table below.

	Primary.			Secondary.			
	E.M.F. at terminals.	Current.	Watts absorbed.	E.M.F. at terminals.	Current.	Watts delivered.	Commercial efficiency.
1	604	72·5	43,790	111·5	320	35,536	81·3 %
2	606	72·5	43,935	111·5	327	36,313	82·5 %
3	588	64	37,632	110·5	280	30,814	82·2 %

Mountain Railway at Barmer.—From the *Frankfurtre Zeitung* we learn that it has been decided to use electricity as motive power on this line. The work will be entrusted to the firm that is constructing the Elberfeld-Barmen line, the contract price being 900,000 marks (£45,000).

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THE SUBWAY DISPUTE IN NEW YORK.

The subway system of New York, if system it can be called, appears to be likely to lead to difficulties as serious as those which it was intended to avoid. As soon as the overhead wires were condemned, several companies were formed to make subways. To tunnel or build a subway in New York is a more serious undertaking than to carry on the same work in the soil of London; and as everything of this nature is treated as a political matter in the United States, the complications of promoters and their policies become very formidable. Several more or less organised bodies mortgaged, or otherwise, disposed of their rights, franchises, and such property as they had acquired, to the Consolidated Telegraph and Electric Subway Company, which is said to have a capital of £625,000. The operations of subway-making for electrical purposes are controlled by a law which provides that the City of New York may, after January, 1897, purchase the system of tunnels, together with their fixtures and rights, for a sum not exceeding the actual cost of the property, with ten per cent. added. Under these conditions, it was natural that the pro-

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moters should have set to work to recoup themselves with more energy than is usual in an undertaking which is not hampered by any such prospective limitation. The Western Union Telegraph Company, which owns the majority of the telegraphic systems of the United States, together with the Bell Telephone Company, were not backward in the matter, and managed to acquire a powerful control of the whole affair. But this did not suit the arrangements of certain patentees, who, of course, had been busy in devising methods of construction. The North-American Underground Telegraph and Electric Company was one of these, and they brought an action in the Supreme Court against the Consolidated Company for an alleged breach of contract in failing to use their patent system of conduits. The North-American Company, however, assert that the Western Union Telegraph Company and the Bell Telephone Company, being "practically the owners and controllers of a certain other corporation known as the Metropolitan Telephone Company," had for their own purposes so managed and controlled the affairs of the Subway Company, and had conspired to prevent the placing of the wires underground, that they claimed damages at £520,000. They also demanded that the Subway Company should proceed to take down overhead wires in New York and place them in their (the North American) patent conduit. It is alleged that the Subway Company had agreed with the North American Company to use a certain conduit made on the Johnstone system. This was laid throughout several miles of streets when operations were suddenly suspended. The stoppage is attributed to the action of the Western Union and Bell Telephone Company, who are said to have such influence with the Metropolitan Telegraph and Telephone Company as to control indirectly the Subway Company; but they appear to push their complaints rather far when they assert that the Consolidated Company have resorted to building useless conduits in order to induce the public to imagine that an underground system is impracticable.

The Consolidated Company, having acquired mortgages of the lesser corporations, have themselves mortgaged £240,000 of bonds to the Atlantic Trust Company, while the Edison Company is mixed up with it to the extent of £24,000, and other electric companies to £240,000. Similar amounts are given to the Mercantile Trust Company, and the whole are payable in June, 1894, at an interest of 6 per cent., or, at the option of the Company, they may be redeemed earlier, at six months' notice on payment of accrued interest and a 10 per cent. premium on the par value.

The counsel for the Brush and two other important electric companies says that, at the outset of the subway movement, two or three years ago, there was some opposition on the part of the United States and the Brush Companies to the use of subways, from an honest belief that it had not been demonstrated that underground distribution was successful. The Westinghouse interests had favoured underground distribution from the beginning. Mr. WESTINGHOUSE preferred to work underground. The Brush and United States Companies now encourage the building of subways, and place their conductors in them as fast as they are ready. They only complain that they are not built fast enough, being convinced by a year's experience that they suit their work and afford a valuable protection to their wires.

We do not suppose that such an extraordinary difficulty as that which exists in New York could take place between rival companies in this country. We have, at all events, some recognised system of obtaining powers to take up streets, after due application and compliance with the regulations of Parliament and the Board of Trade. If a company were formed to carry out in London the work which the Empire City Subway Company proposes to undertake, we believe that several of our supply companies would be ready to avail themselves of the facilities they offer. This company was incorporated with a capital of a little over £100,000, with the object of constructing, manufacturing, maintaining, equipping, operating, leasing or selling conductors, subways, conduits, ducts, and house connections. It would save a very considerable amount of trouble and expense to a London supply company if it could dispense with the worries and red tape that are met with in dealing with vestries and other local authorities, besides enabling a considerable reduction to be made in their staff and plant. The local authorities have been encouraged by Mr. CHAMBERLAIN, and their powers have been materially extended owing to his suggestions. The Board of Trade defer to them in a way that was unknown ten years ago; and the uncertainty as to what will be the nature of their authority five years hence makes it difficult to speculate on the probable result of any matter with which they have to deal. The view of some of the local authorities is that all the new industries of supply—gas, water, hydraulic service, pneumatic tubes, and electric light—impose additional limitations to their control of the streets, and that having had their powers set aside by so many Acts of Parliament, they should have some voice in any new regulations that are made. So far as the control of the streets is concerned, it is probable that the vestries and local boards would recognise the advantages of a subway system; but no sooner does a discussion commence upon a subject in which so many interests are involved, than the leading principle is lost sight of, and the matter becomes so modified and amended that little or no interest in it survives.

REVIEWS.

The Electrical Engineer's Pocket-Book. By H. R. KEMPE. (London: Crosby Lockwood and Son, 1890.)

This is a well arranged and compact pocket-book, and will be very useful both to the telegraphist and to the electrical engineer. It contains 250 pages, besides some sheets of squared paper, and is $\frac{5}{8}$ of an inch thick. It is easy to excuse errors of omission in a pocket-book, since every page saved increases its portability. The greatest fault of the most successful pocket-book—"the indispensable Molesworth"—is its attempt to cover too much ground. Mr. Kempe has doubtless carefully considered the question of the double field of his work, when he has deliberately combined telegraphy with heavy electric engineering. He has Molesworth as a precedent; but we think he makes a mistake. A telegraphist's note-book might be compiled, with about 160 pages, making a book say $\frac{3}{8}$in. thick; and to do this, Mr. Kempe has merely to cut out those pages relating to electric lighting, metallurgy, engines, dynamos, &c. He might compile another pocket-book, embodying the pages discarded from the first, together with much matter, such as resistance of wires, that is common to both subjects. But the second work would, unless it were considerably modified, be distinctly inferior to the first.

The author has evidently expended great pains in the arrangement of the tables. The very first line in the book, which we thought contained an error, is a proof of this. The weight of one cubic foot of water is given as 62·355lbs. Every engineer is familiar with the common 62·425lbs.; but, on closer examination, we find, and we did not remember, that the latter refers to water at its maximum density, while Mr. Kempe assumes (though he does not say so) 62° Fahr. Several neat approximate conversions of metric into English measure are given, and these are supplemented by the percentage of the error which they involve. An excellent rule,

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which we have often used, but which we have never before seen in print, runs:—If two approximate values have to be *multiplied* together, take one value too high, and the other too low, the errors will then tend to cancel each other. If two approximate values have to be *divided* the one by the other, take both values either too high or too low. Among the units we find the calorie, but no mention of the English unit of one pound of water heated 1° Fahr., as used by all engineers. In giving the effect of temperature on electrical resistance, it should be stated that most pure metals follow the same law as copper. We searched in vain some months ago through every book we could find, for the effect of temperature on the resistance of platinum, and discovered nothing but an extremely elaborate Paper on the subject in the *Transactions* of the Royal Society, which gave minute accounts of experiments with curves and theories, and everything about platinum, except the coefficient, which we learned afterwards is the same as that of copper. The sections on testing and measurement are excellent; but we object to the term "joint conductivity resistance," where the joint resistance of two or more wires in parallel is meant. The term "parallel" seems to be carefully avoided throughout the book, and the old expression "multiple arc" is used.

The sections relating to electric lighting, &c., are, as we have intimated, below the high standard of the rest. It is asserted, probably on the authority of Prof. Silvanus Thompson, that a constant-current dynamo can be arranged by providing an independent constant excitement for a shunt machine. This we believe to be impossible. No less than four pages are devoted to as many diagrams of the methods of connecting for series, shunt, separate excitation, and compound. These, together with several other items, are text-book matters; no engineer should need to refer to a pocket-book to refresh his memory about such subjects. One is reminded of the story of the Japanese engineers in charge of a steam engine, who, when an accident was imminent, became so excited that they forgot the formula for stopping it.

The old form of Prony brake with blocks, screws, and lever should be supplemented, if not replaced, by the arrangement of ropes used at the tests of gas engines made by the Society of Arts. No engineer's pocket book is complete without a trigonometrical table, and more space should be devoted to it than is given by Molesworth. In a table of the consumption of fuel, high speed engines are placed at one end of the list, with a consumption of 3·5 to 4lbs. single cylinder high pressure engines 3 to 3·25, single cylinder condensing 2·5 to 2·62, and compound condensing 1·87 to 2. Nothing is said about the size of the engines; and the table as it stands, gives the impression that the engines of, say, Messrs. Willans and Robinson are the most uneconomical of any. The "dictionary of technical terms" which occupies the last 13 pages, might be compressed into less than half the space in smaller type. But who wants to consult a pocket-book to learn what "Armature, Dynamo" means, and there to find that it is "the moving part of a dynamo in which the currents are generated"? The definition of impedance is as careless;—"resistance to the flow of the electric current." But what can we say about the "Positive plate of a voltaic cell?" "The plate from which the current is assumed to flow from the external circuit. The zinc plate and Potential, Electric. The power of doing electric work!"

Notwithstanding these slips, the "Electrical Engineer's Pocket-Book" is a good one, and we venture to suggest that some of our hints might be adopted in a future edition which is sure to be called for at no distant date.

Edmunds on Patents for Inventions. (London: Stevens and Sons, 1890.)

This is, we think, the most complete work on the Law and Practice of Letters Patent for Inventions we have seen. The author gives as his apology for his work that the last really comprehensive treatise on the subject—though, of course, there have been many most useful and efficient minor publications of limited scope—was published by Hindmarch in 1846, that is, prior to the Patent Law Amendment Act of 1852, which made many important and radical changes in the law, but which has itself been superseded by the 1883 Act, under which, and its amendments up to the present date, the practice and procedure both in regard to applications for and grants of letters patent for inventions is almost in every respect different from what it was at the time of Hindmarch's work of 1846. The object, therefore, of the present work is commendable, and will supply the deficiency alluded to.

The book under review deals with its subjects in a thoroughly exhaustive and able manner. It is divided into three parts, each carefully arranged, so as to avoid, as far as possible, confusion, and facilitate reference. We have not space to enumerate the heads of all the subjects individually, as dealt with under these headings, and it must suffice to say that in addition to the new matter introduced by the author in Part I., which occupies 423 pages, there are the Patent Acts and Rules annotated, the International Convention, and a full collection of statutes, forms, and precedents. The history of the law is dealt with, and the functions of the Patent Office. The text contains references to all the precedent patent cases which are now of any importance, dates and contemporary references being also given. Tables are supplied of cases brought up to date, and an appendix of Statutes, Rules, and Forms under the most recent (1890) rules, &c. The author has included an appendix of foreign and colonial patent laws; this latter we think might, perhaps, have been dispensed with, since the book is already of somewhat unwieldy dimensions, and might with advantage have been divided into two volumes. It concludes with a well-arranged and copious index.

The treatise has obviously entailed an enormous amount of labour, care, and knowledge, and it deals with its many-headed subject in an exhaustive manner. It should prove of value to patent agents and others interested in or likely to require information on the subject, and is well worthy of a place in the library of solicitors and others who may from time to time have to deal with the subject of letters patent for inventions and collateral matters connected therewith.

Electricity in the Diseases of Women. By G. Betton Massey, M.D., Physician to the Gynæcological Department of Howard Hospital, &c. Second edition. (London and Philadelphia: F. A. Davis.)

That this little work should have run through one edition within a few months of its first appearance is a sufficient indication that it has supplied a want, and, therefore, to a certain extent, criticism is disarmed.

The exact value of electricity as a curative agent is still somewhat uncertain; the whole question may be very truly said to be yet in its infancy. It is frequently the fate of great discoveries that their first introduction is retarded, on the one hand, by strenuous opposition, and, on the other, by the over-zeal of enthusiasts; out of this conflict of opinions we arrive, in course of time, at a true estimate of the real value of the innovation. We should not like to say that this "true estimate" has yet been attained in the case of medical electricity, but Dr. Massey's book is an example of the process referred to; in it electricity no longer appears as the universal panacea, and no hesitation is evinced in bringing forward cases in which its application was followed by bad symptoms, or in enumerating those in which its use is distinctly contra-indicated. We do not ourselves feel in a position to offer any opinion upon the purely medical aspect of the subjects treated by Dr. Massey; more especially as, in spite of the powerful advocacy of some eminent members of the medical profession in this country, the methods of Dr. Apostoli, with which the work before us is mainly concerned, can hardly be said to be universally accepted or practised in England.

For the rest we may say, that the electrical principles involved are explained in a clear and readable manner, and without undue references to elementary or theoretical considerations. The diagrammatic contrast (Figs. 11 and 12) of the electrical force with a column of falling water strikes us as a particularly happy one, and likely to save the student much time and trouble in his efforts to appreciate the differences between "electromotive force," "resistance," &c. The author has introduced an ingenious "current controller" (Fig. 3), the action of which depends upon the contact surface afforded by a carefully graduated band of graphite; he insists, too, upon the use not

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only of carefully controlled currents, but also upon exact measurements of current-strength. The importance of this latter can never be over-estimated in scientific work; and it becomes an absolute necessity when, as in the class of cases treated by gynæcologists, currents of upwards of two hundred milliamperes are dealt with.

The book is decidedly well worth reading, even by medical men who have not devoted themselves especially to the study of diseases of women.

ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 318.)

§ 7. **Cables at Rome.**—The current supplied by these machines is conveyed into three main conductors, often called the feeders. These consist of concentric cable made by Siemens and Halske, laid in wooden boxes filled in with cement and placed underground.† The construction of this conductor is well known. It consists of a core of stranded copper wires, insulated over with an insulation of jute impregnated with highly insulating material. Outside this is stranded the return conductor of copper wires enclosing the core, as in a tube; then more insulation, and finally a double twist of iron

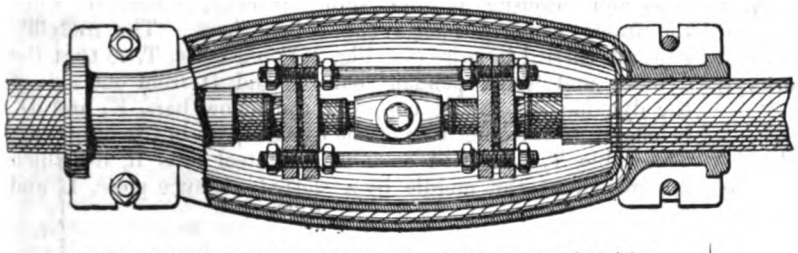

FIG. 21.—Simple straight-joint Coupling in Siemens and Halske Concentric Cable.

or steel tape and hemp protection over that. In Rome there are some 18 to 20 kilometres, or about 12 miles, of this main cable laid up to the present (1890). The cross section of each conductor is 220 square millimetres, or about one-third of a square inch. The main cables are laid in 100 metre lengths, with junction-boxes at this distance.

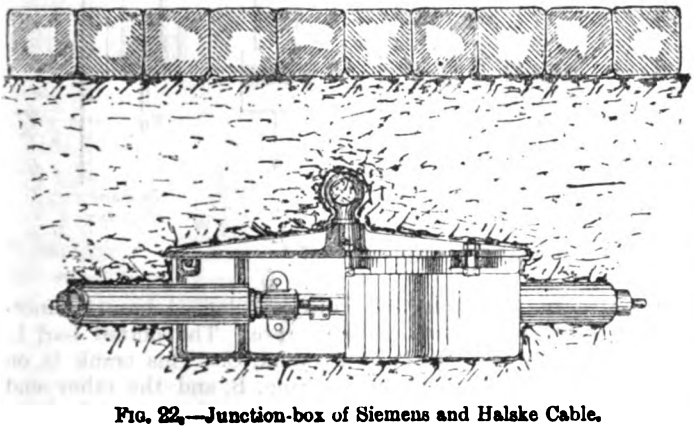

FIG. 22.—Junction-box of Siemens and Halske Cable.

The three main cables all run together to the Piazza Venezia and then diverge off in different directions, the most distant point reached being about 4½ kilometres, or three miles, from the station. The distance from the station to the point of divergence is about 1,600 metres, or one mile. The mode of making the junctions of the different lengths of the cables and of the branches has been most carefully thought out. The junctions are made in cast-iron boxes, in which these junctions are formed by copper straps, links, or clamps, and involve no soldering in making the joint in the street. The lids of the boxes are closed water-tight, and the box then pumped full of rosin oil. The diagrams in Figs. 21, 22, 23, and 24 show the various forms of junction box and mode of making the joint. Beyond the Piazza Venezia, the three mains give off branches in different directions, smaller concentric cable being used and the sub-mains run to the different groups of transformers. At the present date (1890) there are some 125 transformers installed, all being of the same uniform size of 7,500 watts, or 10 horse-power. These transformers are put in singly or in groups

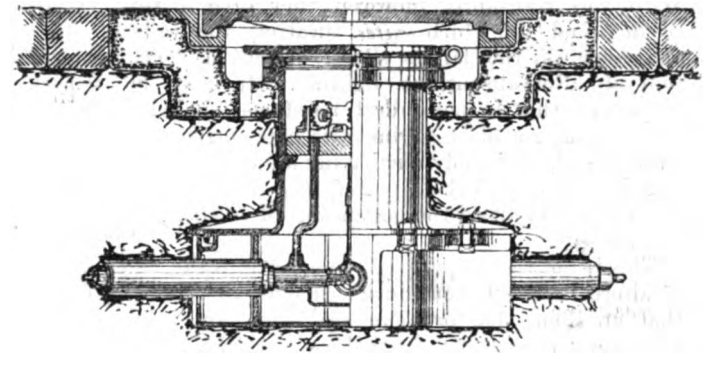

FIG. 23.—Surface-box for branch junction, Siemens and Halske Cable.

arranged in parallel in the various houses and public buildings, and feed about 12,000 100-volt incandescence lamps of 16 candle-power, 10 candle-power, and 32 candle-power, as well as some 300 Ganz alternating arc lamps of 8, 16, and 32 amperes, which are worked off the intermediate terminals of the transformer. The transformers are placed in small fire-proof safes, boxes, or chambers, according to their number, and

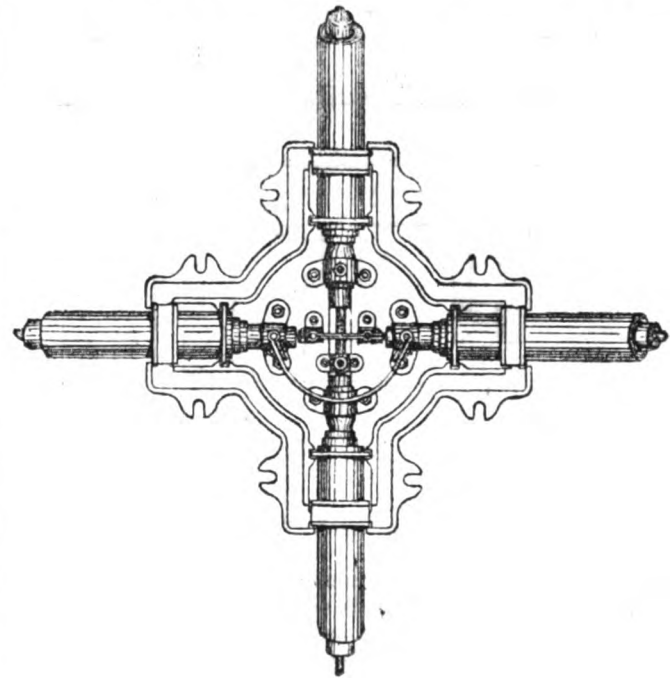

FIG. 24.—Cross-junction, Siemens and Halske Cable.

great pains are taken with the insulation of the primary wires. Bare copper rod is most used for connections and is carefully carried on porcelain insulators, in the transformer rooms where it is possible to do so. In other places highly insulated wire. The transformers each take at full load about four amperes of primary current at 2,000 volts, and give out 75 amperes at 110 volts; the intermediate terminal enabling arc lamps with resistances in series

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† This plan of laying in cement has not been found to be satisfactory. In future it is probable the concentric cable will be laid in wooden troughing filled in with pitch or asphalt.

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to be put on at 55 volts. A number of 10 horse-power transformers banked together is used in each of the large buildings lit. The lighting comprises not only street arc lighting, but lighting by arc and incandescent entirely of theatres, Senate and Chamber of Deputies, post, telegraph and public offices, besides shops and houses; the extreme variation of potential from point to point not being greater than 4 volts, and being regulated from the Central Station by keeping a standard pressure at one of three points in the network. The Argentina Theatre is lit by 1,800 incandescent lamps, and 11 arc lamps, worked off 12 transformers, having their secondary circuits in parallel. Each arc lamp has a resistance in series with it which absorbs about 10 volts, and without this resistance the arc lamps are not found to work steadily. With this resistance, however, they give a very excellent result; and the chief *cafés*, theatres, the railway station, and some of the larger shops, present a very fine exhibition of alternate-current lighting. It may be remarked in passing that a mere dead resistance should not be used for the purpose of steadying alternate-current arc lamps. A choking coil, preferably one having an air gap in it for reasons already given (*see* Vol. I., p. 267, *The Alternate-Current Transformer*), would afford the best means of securing the necessary steadiness.

This is not the proper place to enter into the vexed question of alternate *versus* continuous current arc lamps. The fact that at Rome 300 or more arc lamps are being employed indicates the necessity for making provision for arc lighting; and the economical question which has to be faced is whether the gain in simplicity of working by a uniformity of system is or is not counterbalanced by the disadvantages of intrinsic economy in the alternating parallel-worked arc as compared with series-worked arcs of equal mean candle-power, operated on separate circuits and by separate machines and, perhaps, engines.

§ 8. **Change-over Switch** (Zipernowsky, Déri, Bláthy).—Although the dynamos in the Central Station at Rome are of different sizes, it has been found perfectly possible to work them in parallel together. As a regular rule this is not done, but each one of the three mains is supplied by a separate dynamo according as the load on it requires. As there are six dynamos and three main conductors the problem presented was to connect any one of the six dynamos to any one of the three mains, and to make any necessary change in the combination without extinguishing the lights. This has been solved by the construction of an exceedingly ingenious switch-board which effects these changes with ease and certainty. The switch is an elaborate arrangement, and somewhat costly to construct. It will best be understood by the following diagrammatic sketches.

On a suitable framework is carried a series of pairs of copper bars (see Fig. 25) D_1, D_2, D_3. D_1 and its fellow (not shown) are in connection with the poles of one dynamo. Similarly, D_2 and its fellow are in connection with the poles of a second dynamo, and so on. These bars are carried on insulators, and have pendant iron rods, d_1, d_2, d_3. There are a second series of pairs of copper bars, F_1 and its fellow (not shown), F_2 and F_3, and so on, which are in connection with the two leads of various cables. From these bars F_1, F_2, &c., are also pendant iron rods f_1, f_2, &c., and these are placed near the pendant rods, d_1, d_2, &c. Mercury cups, 1, 2, 3, &c., can be raised or lowered by a mechanism to be described, by which these pendant rods can be put in electrical connection, so that f_1 is joined to d_3, or to d_2, or to d_1, according as mercury cups 1, 2, or 3, are raised up. Hence, we see that the bars, D_1, D_2, D_3, can be electrically joined to the bars, F_1, F_2, and F_3, pair and pair, in any combination; and we must suppose that the fellow bars not shown in the figure, but which are the duplicate bars for the other side of the dynamo, are coupled similarly simultaneously. Suppose, for instance, that the mercury cups, 1, 5, 9, are raised up and the rest kept down; then D_3 is joined to F_1, D_2 to F_2, and D_1 to F_3. Thus, any dynamo can be put on any cable. Supposing that each dynamo is working on a cable, and it is desired to interexchange the positions of the dynamos, this can be done by raising and lowering mercury cups. For instance, let D_1 be joined to F_3, and D_3 to F_1, and let it be requisite to interchange the dynamos. What has to be done is to lower the mercury cups, 1, and 9, and raise the mercury cups, 3, and 7, and, if this is done very quickly, the dynamos and circuits will be interchanged without any sensible interruption of current. The mechanism for raising one group of mercury cups and lowering another, simultaneously, is carried below the frame which supports the copper bars. The mercury cups are carried in pairs (*see* Fig. 26) on a table, T, so that the dynamo and feeder pendant bars, F, and D, from one side of the dynamo, dip in one cup, and the fellow bars, F', and D', belonging to the other side of the dynamo, dip in the other cup. This table, T, is carried on a pair of steel rods R, R', which are crossed at the middle by a slotted distance piece, L, and

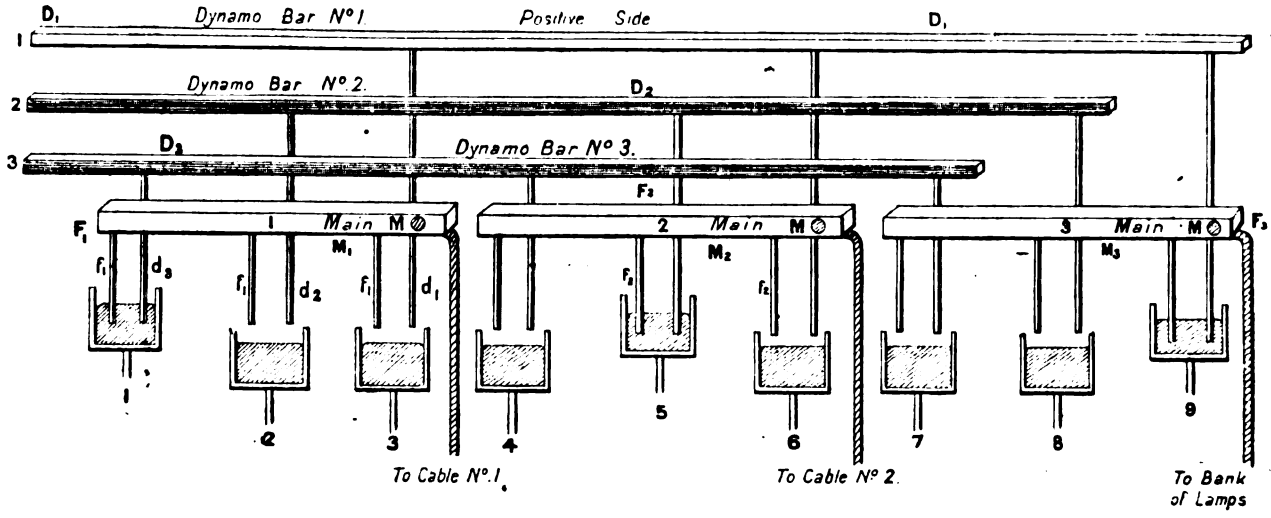

Fig. 25.—Diagram representing one side of change-over switch in central station, Rome.

the weight of the table and cups is balanced by a balance-weight below, not shown in the figure. The slotted bar, L, is traversed by the pin, P, of a crank, C. This crank is on a shaft, Q, working through a bearing, B, and the other end of the crank is supported by a pin, *p*, working in a bearing in the back of a slotted block, S, the slot in which is just wide enough to receive the square web of the crank, C, when the shaft, Q, is pushed forward by the handle, H, as far as it can go. When the shaft, Q, is pushed forward so that the crank arm, C, engages in the slot in the block, S, it is easily seen that the crank can only be moved round with the mitre wheel, W; but that when withdrawn it has an independent motion of rotation. By turning the handle, H, when the crank is disengaged from the block, S, the mercury cups can be raised or lowered through the distance of the "throw" of

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the crank, but, if the crank is engaged in the block, S, then the rise and fall of the table can be effected by a rotation of the wheel, W. The crank can be obviously turned or inserted into the block, S, either in the upper position or in the lower, and then a half-turn of the wheel, W, will either lower the cups or raise them.

Imagine a series of such cranks placed side by side (see Fig. 27) and each supporting its table and pair of mercury cups; and suppose the mitre wheels, W, attached to each shaft to engage in a series of mitre wheels, W', all keyed on one long shaft. If a handle, K, is given half a turn, it will turn all the slotted blocks, S, half round, and it will raise, or lower, or not move, the table corresponding to each crank, according as that crank has been engaged previously in the slotted block in the upper or lower position, or withdrawn so as not to engage at all.

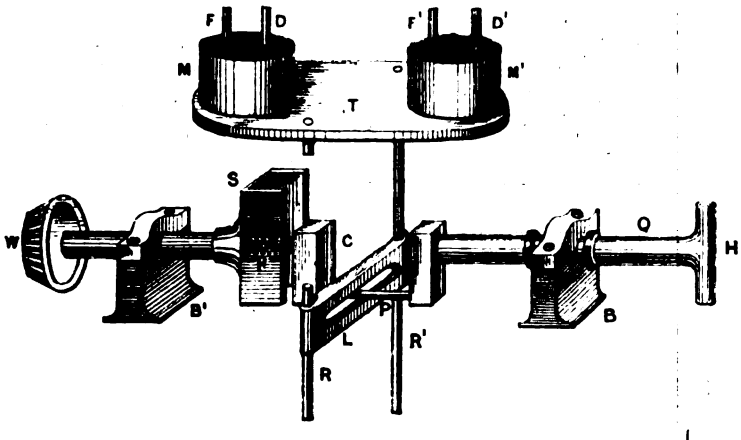

Fig. 26.—Diagram representing Cranks for Raising or Lowering Mercury Contact Cups in Change-over Switch at Rome.

It is, therefore, obvious that by an appropriate position for each handle, any of the pairs of mercury cups can be caused to rise, or fall, or not to be moved, when the handle, K, is turned half round. Returning to Fig. 25, we can now see that a mechanism can be suitably arranged to effect simultaneously the electric connection or disconnection of any dynamo from any main, and that any possible combination can be instantaneously exchanged for any other.

In the change-over switch at Rome there are four pairs of bars corresponding to the three mains, and to a bank of 3,600 lamps which is used as an artificial load on which to run up each dynamo to speed.

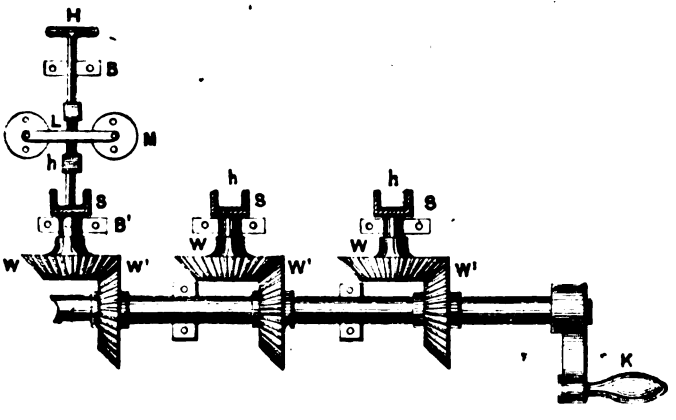

Fig. 27.—Diagram of Mitre-wheel Arrangement in Change-over Switch at Rome.

If any main is being operated by any dynamo and it is desired to replace this dynamo by another, the incoming dynamo is first run up to the same amperes and volts as that of the circuit dynamo it is about to replace. The change-over switch is then brought into action to interchange the dynamos working on the circuit and that working on the artificial load; and so perfect is the operation of this switch that, when smartly worked, not the slightest wink can be seen on the circuit lamps. This switch is used to replace the small day dynamos by the bigger ones, at nightfall, and when required, or to effect any interchange necessary. It is, no doubt, an expensive switch-board to construct, but it does its work admirably.

(To be continued.)

PICKING-UP MACHINES FOR CABLE SHIPS.

In connection with Mr. H. D. Wilkinson's recent article on "Improvements in Cable Ship Gear," a few particulars of the machinery first used in repairing cables may, we think, prove of interest to our readers.

The first example is the recovering of the Donaghadee and Port Patrick cable, which had been paid out for sixteen miles, when the tide and wind swung the ship round stern to wind and tide, and the cable had to be cut about five miles from the land in about 180 fathoms.

Mr. R. S. Newall had a picking-up machine made, consisting of two drums of equal diameter, with grooves and spur-wheels, which geared into a pinion between them. The cable came from the bow sheave to the sternmost sheave, took half a turn in a groove, and then went under the foremost sheave half a turn round, and on to top of the sternmost sheave, on to the second groove, and so on for five half turns on each drum. The machine was fitted on board the Electric Telegraph Company's ship "Monarch" (the first telegraph ship), which had been chartered by Mr. Newall, and the whole sixteen miles were recovered. This machine was never used again.

In 1854 Mr. Edwin Clark and Mr. F. C. Webb designed the first single-drum picking-up machine. It was made to work with handles, which extended to bearings on the gunwale on each side, so that some twenty men could be put on to each handle, and several lifts were thus executed by manual power. There was a ratchet-wheel attached to the drum to prevent accidents in case the cable was deep in the ground and the ship pitching. But soon an engine was used, with a strap from the fly-wheel of the engine to a pulley on the last pinion shaft. The drum had a knife to fleet the turns, as on a paying-out drum. There was no hauling-off gear, and the cable had to be kept tight by men hauling at it. A hauling-off gear was added about 1857. The drum had bearings on both sides, so that the cable could not be got off without cutting it.

In 1863 Mr. F. C. Webb designed the machine for the "Amberwitch," the repairing ship for the Persian Gulf cable. In this machine the bearings are both on the same side of the drum, which is carried on an overhanging shaft. The turns of cable can be taken off therefore, without cutting the cable. A pinion worked into an internal spur-wheel, and was attached to the drum on the outside of which was the brake. By having the spur gearing connected to the drum itself, no strain was thrown on to the spokes of the drum, which was the case when the spur-wheel was on the shaft and detached.

There were two knives for fleeting, the one in front for picking up, and the other behind for paying out. To take the turns on the drum off, the stern knife had to be moved away from the drum. This was effected by taking out a cotter, which was provided with a handle, when the knife fell away from the drum, and the turns could then be taken off. There was a hauling off gear to this machine, which slid sideways on its shaft, so that when the turns of cable moved from one side (when picking up) to the other side (when paying out) the grooved wheel could adjust itself to the proper position. This machine did its work for a good many years in the Persian Gulf; but of course there are many improvements now, though Mr. Webb is of opinion that the large spur-wheel should be always attached to the drum, and not, as in some machines, even of recent date, be separated from one another, thus throwing a strain on the spokes of the spur-wheel, and on those of the drum, besides torsion on the shaft, and a strain on all the keys. The machine fitted to H. M. telegraph steamer "Monarch" has these defects.

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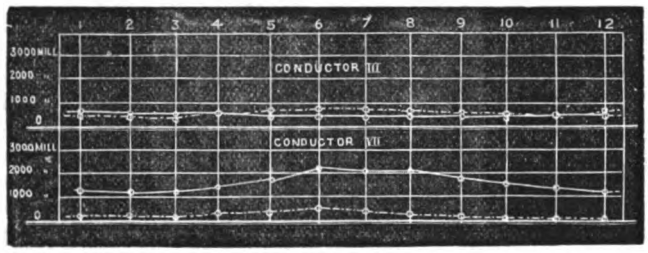
INSULATION MEASUREMENTS ON SOME GERMAN UNDERGROUND CABLES.*

BY C. GRAWINKEL.

The German underground cables have since their laying been subjected to regular tests and measurements at the hands of the Postal Telegraph Engineers' office. These observations, extending now over a number of years, lead to important conclusions as to the behaviour of the cables. The measurements taken relate to the resistance of the conductors (seven in number) constituting the cable, the capacity, and the insulation resistance. Of these, the two former are of comparatively small importance, whereas careful records of the insulation resistance extending over a considerable time, may offer some guide as to the direction in which improvements are to be sought. It is on the properties of the gutta-percha covering then that interest is concentrated.

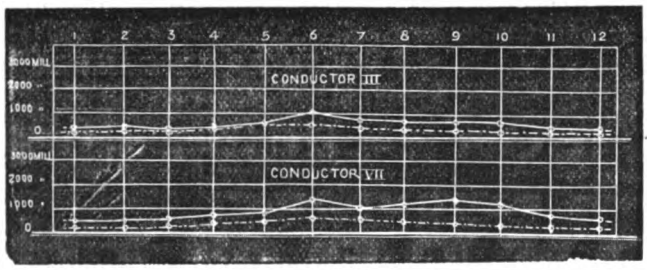
The oldest of the cables is that from Berlin to Halle, regular measurements of which have been taken since 1877, those most recently laid being from Berlin to Danzig, Thorn, Posen, and Stettin, for which measurements since 1882 are at hand.



FIGS. 1 and 2.—Berlin-Halle.

The results of some of the measurements are shown in Fig. 1. The insulation resistances of definite conductors, reduced to one kilometer in length and a temperature of 15°C., are shown by the curves, the mean values for each month in millions of Siemens' units being the ordinates, and the abscissæ representing the time, the Figs. 1 to 12 standing for the months of the year. In each case the full line shows the first available measurements, whilst the dotted lines are those for the year 1889.

Figs. 1 and 2 give the results in the cases of conductors 3 and 7 of the Berlin-Halle cable for the years 1877 and 1889, and Figs. 3 and 4 those for the Berlin-Hamburg cable in 1879 and 1889. The Berlin-Hanover cable shows similar curves.



FIGS. 3 and 4.—Berlin-Hamburg.

The curves for these cables show a great resemblance. It will be noticed that the insulation rises during the summer months, as is shown particularly clearly by conductor 7. Conductor 3 also shows this to a smaller extent for the year 1889, the maximum occurring in June and July. The curves for conductors 1, 2, 4, 5, and 6, which with 3 surround conductor 7, are not given, as they are similar to that for 3. It is surprising to find that whilst the insulation of conductor No. 7 has in all three cables dropped considerably (notably in that from Berlin to Halle), that of No. 3 has dropped very slightly, and is even in some cases higher than its original value.

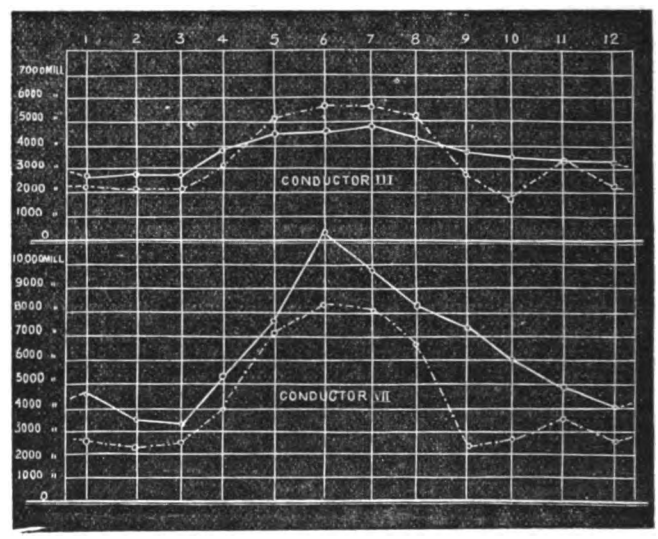
In Figs. 5 and 6 are given the measurements for 1881 and 1889 for the cable to Frankfurt-on-Oder. The Dresden and Thorn cables present the same features.

These curves again show a rise in insulation during June and July. On conductor No. 3 the value is sometimes above and sometimes below that taken in the earlier year; whereas No. 7 shows a general fall, although at times it also rises above its original value.

It will be seen that these cables divide themselves so far as regards their insulation into two classes. In the one, including the first laid cables from Berlin to Halle, laid 1876; from Berlin to Hanover, laid 1878; and from Berlin to Hamburg, laid 1877, the variations are small; whilst in the second, including the cables from Berlin and Frankfurt-on-Oder and Breslau, laid in 1880, Berlin to Dresden, laid in 1879, Berlin to Posen and Thorn, laid in 1880; Berlin to Stettin, laid in 1881, the fluctuations are of considerable magnitude.

Before proceeding with the deductions to be drawn, a short explanation of the way of carrying out the measurements may be given. The resistance of a core of a conductor is first measured by means of a Wheatstone bridge. From the known normal resistance at 15°C., the temperature at which the cable stands can be determined, and then by the help of a correction-table drawn up for every half degree, the insulation at the normal temperature can be obtained. At this point it should be noted that it is not likely that the whole of a long cable will be at the same temperature, considering that it is laid along streets, on and under bridges, and even carried through watercourses. The measured resistance of the conductor gives only the sum of the resistances of the various parts at their respective temperatures. The mean temperature determined in this way will give rise to errors in arriving at the insulation resistance with the help of the temperature corrections. To show this by means of a simple example it may be supposed that half of a cable is at a temperature as much above 15° C. as the other half is below that point, so that the mean temperature is still 15° C.

If the insulation resistance of the whole cable at 15° C. is R, that of each half is 2 R. At a temperature $t°$ higher the insulation resistance of the half is $2\,R\,a^{t}$, and that of the other half at $t°$ lower is $2\,R\,a^{-t}$, where a is a constant, which is approximately



FIGS. 5 and 6.—Berlin-Frankfort-am-Oder.

equal to ·876. These two resistances must be regarded as in parallel, so that the total insulation resistance of the two halves is

$$\frac{4\,R^2}{2R\,(a^{t}+a^{-t})}=\frac{2\,R}{a^{t}+a^{-t}}$$

The ratio of the two resistances, R and $\frac{2\,R}{a^{t}+a^{-t}}$, ought to be = 1. Instead of this, however, it will be found (by expanding) that the ratio is equal to

$$1+\frac{(t\log a)^2}{2}+\frac{(t\log a)^4}{24}+$$

$\log a$ being = − ·132.

The second term in the correction may be neglected, the error arising from this being only ·7 per cent. when $t=5$.

The corrections thus required are—

t	1°	2°	3°	4°	5°
Error per cent.	·9 ...	3·5 ...	7·8 ...	14·9 ...	22·7

No sufficient observations are at present available to determine the range of temperature at which the various parts of a cable may be.

It may therefore be pointed out that other variations in temperature may affect the result obtained, besides those derived from the measurements of the resistance of the copper core. According to the yearly returns of the meteorological station at Eberswalde in 1886, at a depth of ·9m. (that of the cable being usually 1m.), the lowest temperature observed − ·1°C. was in the middle of March, the highest, 17·8°C. on September 5th. Cable measurements on the Berlin-Frankfort line gave − 1·6°C. on March 12th, and 19·8°C. on September 10th.

* Abstract of a Paper read before the *Elektrotechnische Verein.*

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These considerations, however, must be applicable proportionately to all land cables, and they therefore cannot account for the great difference observed between the two classes of cables.

The ordinary theory of insulation with regard to time (assuming the properties of gutta percha to be always the same) should give a straight line for each cable. The curves for the first three cables do not differ greatly from a straight line, whereas the others do, so that the fluctuations must be assigned to different causes in the two classes. The cause can only be sought for in the quality of the gutta percha covering, so that the insulation depends on the gutta percha used as well as on dimensions and temperature. It is highly probable, therefore, that the constant given above for gutta percha as 0·876 is not applicable to every specimen of that material, and the special figure for any particular cable must be known in order to judge of its behaviour.

It is possible that the quality of the material varied owing to the extraordinarily heavy demand for it during the years in which the extensive German networks were laid down. At the same time the great difficulty of determining the absolute resistance of gutta percha prevents this being regarded as a proof, although the curves seem to admit of no other explanation. Further investigations in this direction will take place.

It remains to investigate the conclusions to be drawn from one pair of curves. In the summer months the insulation regularly rises. This cannot be imputed to errors of observation. The cause lies in the fact that the surface of the earth is gradually drying up, so that in spite of the rise of temperature, no fall in resistance takes place.

Another point is that the insulation of conductor 7 has fallen very considerably, according to the measurements of the last years. In all the cables it has the highest resistance, being surrounded by the other six conductors. The fall in insulation can only be attributed to the fact that moisture gradually penetrates with the yarn which fills the space between the conductors, and so the properties of the covering of No. 7 in time change, and No. 7 approaches in insulation resistance the other six.

It will be seen that measurements in the case of land cables present important difficulties. Few of these enter in the case of marine cables: these lie throughout their length in water, and differences of temperature at various points cannot exist, and the insulation resistance can hardly vary. Conclusions with regard to the behaviour of a land cable are not to be trusted, until specific resistance at normal temperatures is determined with greater certainty. The ordinary test for cables, by immersing a fixed length in warm water, affords no criterion for their behaviour when laid underground, and it is only by careful observations continued for a considerable length of time that any valuable result can be obtained.

THE DISCHARGE OF ELECTRICITY THROUGH GASES.*

BY ARTHUR SCHUSTER, F.R.S.

"If we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions, which behave like atoms of electricity."—HELMHOLTZ (Faraday Lecture).

A gas in its normal state contains no free ions, but if through any chemical or physical causes the molecules are broken up in an electric field, ions form, and the gas becomes a conductor. Supposing the difference of potential of two electrodes is gradually increased, a point will be reached at which a spark will pass, that is to say, the molecules will be broken up by electric forces, the positive ions diffusing towards the kathode will tend to form a polarising layer of finite thickness, increasing in width as the pressure diminishes. If the discharge becomes steady, the decompositions are continuously kept up at the kathode, the negative ions being projected with great velocity away from it. These ions will move through the so-called dark space without much loss of energy by impacts; but when, probably owing to sufficient diminution in the electric force, the impacts become more frequent, the translational energy becomes transformed into the luminous vibrations of the glow. The positive ions forming an atmosphere round the kathode must have a greater velocity the nearer the kathode, where their energy becomes visible in the first luminous layer. Whether decompositions take place only at the electrode or through a finite distance from it, is at present an open question; nor can we decide as yet whether the negative molecules projected outwards are the main carriers of the current inside the dark space. In the dark space the negative ions will accumulate and meet the positive ions proceeding from the positive part of the discharge. We shall expect at some point towards the outside of the glow the free ions to become more numerous than in other parts of the discharge. Here we find a small fall of potential and no luminosity; this is the dark interval separating the positive part of the discharge from the negative glow. A number of ions probably reunite in this part to form molecules, and in case it should ultimately be found that positive and negative ions diffuse with the same velocity, we should have to conclude that as many molecules as are decomposed at the kathode recombine in this dark interval. If, as seems more probable to me, it should be found that the negative ions diffuse more rapidly, the recombination will in part take place at the anode. If the conditions in the tube are such that the gas may divide into layers, such that in alternate strata the decompositions outnumber the recombinations, and *vice versâ*, stratifications will form.

Such is the general outline of the theory, which may have to be modified in detail, but which I believe has a strong element of truth in it.

The possibility of a volume electrification is denied by some of Maxwell's disciples, who look on a current of electricity as on a flow of an incompressible liquid in a closed circuit. But there is nothing, as far as I can see, in the conclusions I have drawn from the gas discharges which is inconsistent with the fundamental tenets of Maxwell's theory, however much they may disagree with the accessory embellishments with which that theory is occasionally adorned. There may be a volume electrification without interfering with the equation of continuity of an incompressible liquid as long as we admit the possibility of displacement currents and displacements in conductors; and I see nothing improbable in this. The ordinary equations for the currents in a non-homogeneous solid (or any solid if inequalities of temperature are taken into account) give a volume electrification which can only be destroyed by the introduction of a quantity which is analogous to hydrostatic pressure, and the sole purpose of which is to destroy all electrifications except at the surface of bodies. We know of no physical phenomena which can justify the introduction of such a quantity, which seems to me unnecessary. The existence of a volume electrification can be shown to exist when a current passes from one liquid to another floating on its surface. Chemical effects are observed in the region in which the liquids begin to mix, and these can be explained by the electrification which accompanies each change in electric conductivity. Maxwell's equations assume conductors to be homogeneous throughout; whenever we are dealing with average effects only, this assumption is justified. We deduce, in a similar way, the equations which represent the transmission of light by assuming that each transparent body is replaced by a homogeneous medium having certain properties. But although this simplification is allowable in discussing some of the phenomena, there are others in which it becomes necessary to go a step further, and, considering the structural constitution of the body, to take into account separately the effects of the medium separating the atoms, and the effects of the atoms themselves. In all branches of physics we are gradually forced by the advance of knowledge to abandon the assumption of homogeneousness, and if that is done, no further difficulty stands in the way of bodily electrifications; for we may take them to be really only surface electrifications between the atoms and the medium.

I have offended in another manner against so-called modern views of electricity, for I have spoken of positive and negative electricity as real substances possessing a separate existence. I have tried to place myself, however, under the shelter of recognised authority by quoting at the top of this lecture Helmholtz's saying that we have as much ground for the supposition that electricity has an atomic constitution as we have for the atomic constitution of matter. We must trust to the future to bring this view into harmony with the electro-magnetic theory of light, which may be accepted now as an established fact. There is no real antagonism between the two views. If ever we are able to explain chemical and gravitational attraction by the stresses in a medium, we shall still find it convenient to speak of atoms and molecules; and in the same way the belief in an electric strain and stress is consistent with a belief in something in the atom from which the strain proceeds, and which may be taken as the elementary quantity of electricity. Even taking the extreme view that electric stress is due to vortex filaments in the ether, we need only assume all these filaments to have the same intensity, and some to end at the surface of atoms, in order to reconcile apparently antagonistic views. But there is no need to commit ourselves at present to any particular ideas. In some electric phenomena we shall find it most convenient to speak of electric strain and stress (displacement I think to be a misleading term, which, however, has come too much into use to be dispensed with); in other, and at present more numerous, cases, we shall still continue the old nomenclature, and speak of positive and negative electricity as real quantities. The subject of electro-chemistry is one of primary importance in the present state of science. The different behaviour of positively and negatively electrified particles points, as I have tried to explain, to an unsymmetrical modification of molecular forces by electrification. It is not sufficient to add geometrically the effects of molecular and electrical action, but it is necessary to take account of the inter-

* Concluding section of a preliminary communication to the Royal Society. Received and read March 20, 1890.

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ference between chemical and electrical forces. The exact nature of this interference must partly be solved by chemical investigation, but the discharges of electricity through gases still promise a rich harvest to the investigator.

THE ELECTRICAL TRAMWAY IN PARIS.

Experiments with the working of tramways by electricity are being continued in Paris by the Northern Company on the line between Levallois and Madeleine. Four cars are practically worked, and the Société Française d'Accumulateurs Electriques (Faure-Sellon-Volckmar), who supply the motive-power at the rate of 3d. per car and kilometre, are of opinion that the traffic will be permanent. The motive power is furnished by Faure-Sellon-Volckmar accumulators, with double plates. The batteries are divided in twelve boxes, each containing nine elements coupled in series, 108 cells in all, and as each element weighs 15 kilos., the total weight of the battery is 1,620 kilos.

The twelve boxes are placed in cupboards in the corners of the car—four in front and eight behind. The connections are so arranged that the elements, when the boxes are fixed in their places, become automatically ranged in groups of three by three boxes behind each other, so that there are four groups in all of twenty-seven elements ranged after each other. These four groups may be connected for work in four different ways, as at the Birmingham tramway.

The various connections are effected by the aid of a commutator, consisting of a wooden cylinder, with contacts on the surface. The cylinder is turned by a handle.

The electrical motor is of Siemens' construction, and situated below the car in front. The number of revolutions may be raised to 1,600 a minute, but under normal working it is 1,000. The power is transmitted to the wheels of the car through gearing, which reduces the speed in the proportion of twenty-six to one.

The motor is reversed by the use of a double set of brushes. The cars weigh 3,500 kilos., there being 1,600 kilos. of accumulators and they carry 50 persons. During ordinary speed of 11 kilometres (6·85 miles) an hour the electrical work required is as follows:—On level road, 4·3 horse-power (16 amperes × 200 volts); on incline of 1 in 100, 7·8 horse-power (29 amperes × 200 volts); on incline of 1 in 50, 11 horse-power (42 amperes + 200 volts). With a speed of 9 kilometres (5⅝ miles) an hour and an incline of 1 in 33, 12·3 horse-power (46 amperes × 200 volts) are required. On an incline of 1 in 25, 15·3 horse-power (57 amperes × 200 volts). Finally, with a speed of 5 kilometres (3 miles) an hour and an incline of 1 in 20 the force is 10·2 horse-power (38 amperes × 200 volts), and on an incline 1 in 18 10·75 horse-power (40 amperes × 200 volts).

ELECTRIC LIGHTING IN ST. PANCRAS.

An elaborate report of the Electricity Committee of St. Pancras Vestry—the only local authority in London which has decided to provide the electric light on its own responsibility—was presented on Wednesday last to the Vestry. The Committee reminded the Vestry that the latter authorised them to obtain plans, specifications, estimates, and tenders for carrying out a first installation for the supply of electricity for the purposes of light and motive power of an extent sufficient for 10,000 incandescent lights; the mains being sufficient for 25,000 lights of 16 candle-power each and 90 arc lights. The Committee had divided the work into seven sections, and invited a tender for each. The Committee recommended that tenders amounting in the aggregate to £50,946. 4s. 3d. be accepted. Although having every confidence in their engineer, Prof. Robinson, the Committee had thought it well to submit the plans and specifications to Dr. Hopkinson, President of the Institution of Electrical Engineers, and Mr. Preece, F.R.S., Chief Electrician to the Post Office. Mr. Preece, in his report, stated that "he had in many cases been called upon to consider the best system that should be adopted in various districts. He considered that in selecting the Direct Continuous Current System they had done quite the best thing. He regarded the plans and specifications as very complete, as thoroughly considered, and well worked out." Finally, Mr. Preece observed, "I think that the Vestry of St. Pancras is doing a wise thing in carrying out this installation, and I see no reason whatever, from the careful consideration I have given to the plans submitted, why it should not obtain all the results that have been foreshadowed. The ratepayers will secure the light at the cheapest rate, and the profits accruing from private lighting can be devoted either to the reduction of rates, or to the expense of public lighting." The committee recommend that the seven tenders mentioned in the report be accepted, viz:—

1. Buildings, Kirk and Randall	£4,629	0	0
2. Boilers, &c., the Babcock and Wilcox Company	3,674	10	6
3. Engines, dynamos, &c., Willans and Robinson	16,327	0	0
4. Switchboards, the Electric Construction Corporation	1,313	1	9
5. Batteries, the Electric Construction Corporation	2,745	12	0
6. Trenches for five miles of mains, Mowlem and Co.	9,501	0	0
7. Electrical conductors, 5 miles for private lighting, and 5½ miles for public lighting, Clark, Muirhead, and Co.	12,756	0	0
Total	£50,946	4	3
Add for royalty	909	0	0
Total	£51,855	4	3

It was decided to defer the consideration of the Committee's report.

THE DOUBRAVA ARC LAMP.*

The principle of this lamp is shown by Fig. 1. A and B are fixed electro-magnets, placed one at the top and the other at the bottom of a parallelogram consisting of rods of soft iron, which constitute their cores. C and D are movable solenoids, each sliding no one of the vertical portions of the parallelogram, which at the same time form cores for the solenoids. P is a pulley over which passes a cord, from the ends of which the solenoids C and D are suspended: below these are fixed the carbon holders E and F. When a current traverses the electro-magnets A and B the cores become magnetised, and their poles N N S S arrange themselves as shown. In a like manner, when a current passes through the solenoids C and D, two poles *N N*, *S S* are formed; so that in the solenoid C the pole *n* is attracted by the pole S of the parallelogram and *vice versâ*. A downward motion, indicated by the arrow, will thus be imparted to the solenoid C.

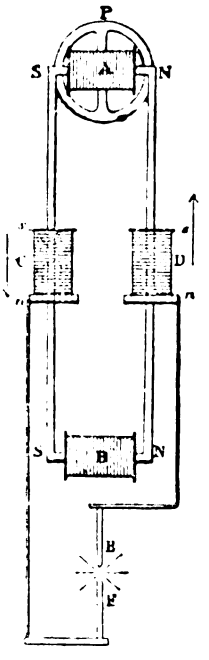

Fig. 1.

In the same way it is obvious that the solenoid D will have an upward motion imparted to it. These two solenoids being connected by a cord passing over the pulley P, their movements take place together, and the carbons are separated. If the direction of the current in the solenoids is reversed, this movement will also be reversed and the carbons will be brought together. On this principle Dr. Doubrava has constructed two lamps, one designed to work in parallel and the other in series.

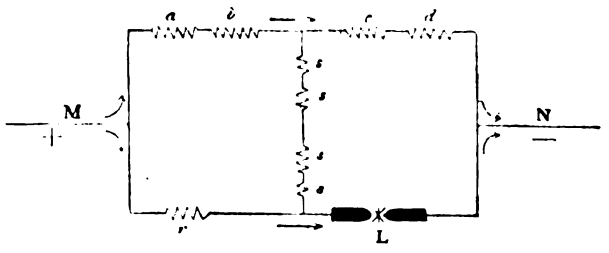

Fig. 2.

The connections of the lamp for parallel working are shown diagrammatically in Fig. 2. The electro-magnets *a*, *b*, *c* and *d* have a resistance that balances that of the arc L and the resistance *r*. S S S and S are four solenoids, which, when the arc is of normal length, should have no current passing through them. When the arc becomes too long a portion of the current goes through the solenoids in the direction M *r s c d* N, and the carbons are brought together. When, on the other hand, the arc is too short, the path is M *a b s* L N, and a portion of the current goes through the solenoids in an opposite direction to that which it formerly did, and the carbons are separated.

* From the *Revue Internationale de l'Électricité*.

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Fig. 3 gives diagrammatically the principal connections in the series type of lamp, as constructed by Steinlen and Co., Mulhouse. of A and B are the + and − terminals respectively. E E are the upper and lower electric magnets, S S are the thick wire solenoid coils forming part of the main circuit, and *s s* are fine wire coils arranged as a shunt to the arc. These two coils are, it will be seen by the

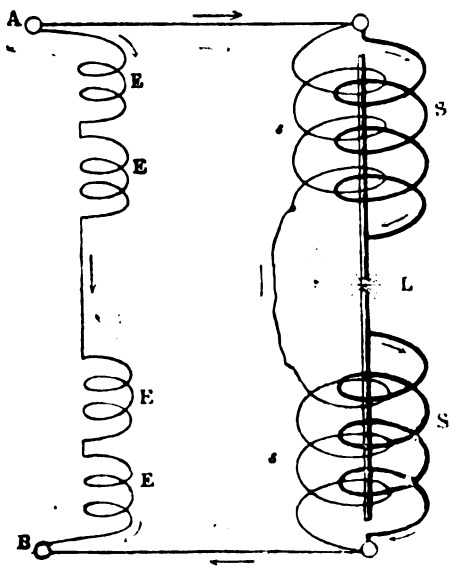

Fig. 3.

figure, arranged to act differentially. This lamp also possesses a cut-out, which introduces such a resistance into the circuit as to compensate for that of the arc. These additions, as well as other modifications, made with the object of perfecting the primary apparatus, are due to M. Schlick, the engineer of the firm of Steinlen and Co.

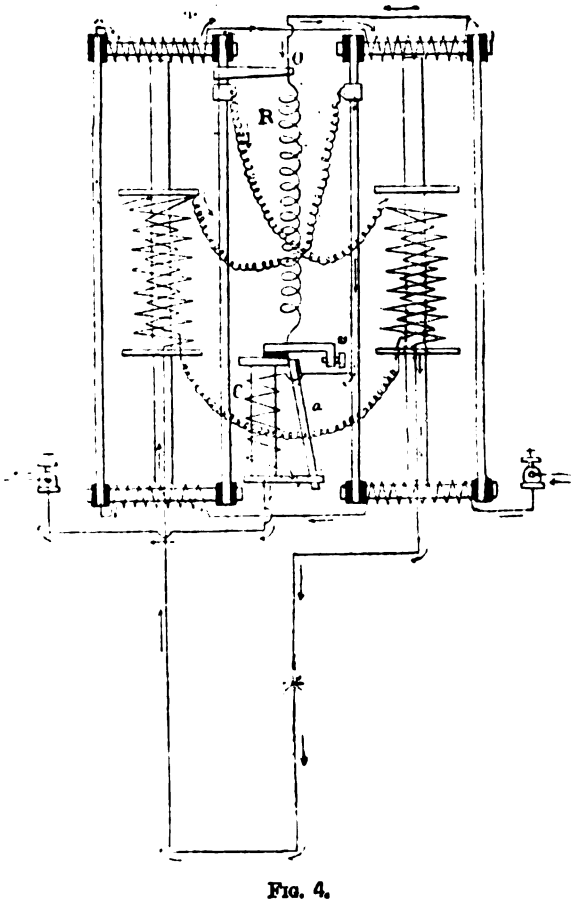

Fig. 4.

The annexed diagram (Fig. 4) shows all the connections in detail of the type of lamp which worked at the Paris Exhibition. The current enters by the + terminal and passes in succession through the four electro-magnets. When it arrives at the point O it is divided into two portions, the most important of which passes through the resistance R, and the armature *a* of the cut-out C, which is not now attracted by the electro-magnet. The current then leaves the lamp of the terminal. The other portion of the current passes through the fine wire of the solenoid, and the thick wire of the cut-out. It is sufficient to actuate the solenoids, and bring the carbons in contact, and thus open a new path of small resistance for the current. The current then passes along the thick wire solenoids, and strikes the arc, the cut-out also attracts its armature, cutting the resistance out of circuit. The feeding of the arc is effected in the manner we have mentioned above. When the carbons are burnt out the armature *a* is brought into contact with *v*, and the resistance R is substituted for that of the arc.

This lamp is extremely simple. The only piece of mechanism it requires is a little catch to prevent the carbons from moving too far apart when the arc is struck. For this purpose the pulley over which the cord passes from which the solenoids are suspended, is provided with ratchet teeth, which come in contact with the catch in question, when the carbons move apart. This catch has, however, a certain amount of play, and the teeth when pressing against it push it by just the amount sufficient to produce an arc of the required length.

LEGAL INTELLIGENCE.

Gibbs and Others v. Ferranti.

In the House of Lords on Friday the case of Gibbs and Others v. Ferranti came before the Lord Chancellor, Lord Herschell, and Lord Morris, in the form of an appeal by Mr. John Dixon Gibbs and the National Company for the Distribution of Electricity by Secondary Generators (Limited) from the decision of the Court of Appeal affirming the judgment of Mr. Justice Kekewich, who, on a petition presented by Mr. Sebastian Ziana de Ferranti, ordered that the Gaulard and Gibbs's patent, No. 4,362, A.D. 1882, should be revoked.

Mr. ASTON, Q.C., and Mr. J. C. GRAHAM appeared for the appellants; while Sir H. DAVEY, Q.C., and Mr. MOULTON, Q.C., represented the respondent.

Mr. ASTON, Q.C., in support of the appeal, said the matter in which this appeal arose was a petition presented by the respondent for the revocation of the letters patent, No. 4,362 of 1882, granted to Lucien Gaulard (since deceased), and John Dixon Gibbs, for a certain invention of "a new system of distributing electricity for the production of light and power;" and the question for decision was whether the letters patent should be revoked. The construction of the secondary generators was fully and clearly described in the specification of the patent; and, as stated by Sir W. Thomson, who was called as a witness for the petitioners, the generators, though not novel, were of special construction, and were described by the patentees, because they were specially adapted to effect the objects aimed at by their invention. The successful working of the new system claimed by the patentees and described in their specification depended upon the conjoined operation of three elements, which were not claimed separately, that was to say—(1), an alternating dynamo supplying electricity in a state of high tension; (2), a long main wire conveying electric currents of high tension in alternate directions, to and through local stations; and, (3) local secondary generators, such as those described by the patentees, operating at each station to supply induced electricity for doing local work. In the year 1884 the invention of the patentees was put into successful operation by the installation of a complete system on the Metropolitan Railway, consisting of a central station at Edgware-road, connected by a main wire about fifteen miles long with local installations at Notting Hill Gate, Gower-street, King's Cross, and Aldgate. An alternating dynamo machine caused alternating currents of high tension to pass along the main wire and generate, by means of the secondary generators placed at each local station, secondary currents, which were successfully employed in the respective stations for lighting purposes. Such use of secondary generators and secondary currents was, as the witnesses for the petitioner against the patent all admitted, wholly new. Not one of them had ever seen or known of such a system of electric lighting having been before used either in the United Kingdom or anywhere else. Since the year 1884 the system of the patentees had been successfully employed at home and abroad, particularly in the United States of America. It was suggested during the trial before Mr. Justice Kekewich, and in the Court of Appeal, that prior to the date of the letters patent a number of propositions had been made and described in the specifications of prior patents for using high-tension alternating currents in a manner similar to that described by Messrs. Gaulard and Gibbs in their specification. It was, however, proved in evidence, and the Court of Appeal were satisfied that it had been proved, that all those alleged anticipations were deficient in material respects. In fact, none of them described the use of the elements whose combined operations made the system of Messrs. Gaulard and Gibbs a success. The specification of the invention patented by Gaulard and Gibbs contained three claims—firstly, the privilege of exclusively working the process of distribution, and the employment of an alternating current of high tension for the generation of an unlimited number of secondary generators and induced currents individually utilised either for the production of light or motive-power; secondly, the system of electric distribution; and, thirdly, the special construction of secondary generators designed to produce this result. After the presenta-

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tion of the petition, the appellants were advised that the third claim was of doubtful validity, for the reason that it might be said that the secondary generators claimed were not new apart from the system in which it was proposed to use them, as described in the specification, and claimed in the first and second claims. The appellants accordingly applied to Mr. Justice Kekewich for leave to amend their specification by striking out the third claim and certain portions of the specification. On the 21st November, 1887, the learned Judge made an order, granting the leave asked for, and in pursuance of that leave the specification was amended. By that amendment the third claim was struck out, and in other respects the specification was amended; but both before and after the amendment, it in fact described and claimed the invention—that was to say, the combination of elements forming a system of distribution of electricity that was new and useful at the date of the patent. The appellants maintained that that was not the case, and that the sole effect of the amendment was—firstly, to narrow the exclusive grant originally made by the letters patent, by striking out the third claim; and, secondly, to strike out some explanatory passages in which the inventors, by the imperfect lights of the scientific knowledge of 1882, endeavoured to explain the principles on which their apparatus worked, which passages were shown by recent science to be more in the nature of imperfect analogies than scientific statements. He (the learned counsel) contended that the letters patent were valid in all respects; that the specification particularly described and ascertained the nature of the invention for which the letters patent were granted and in what manner it was to be performed; that the specification, when amended, did not claim an invention substantially larger than, or substantially different from, the invention claimed by the specification as it stood before the amendment, and that therefore the decision of the Court of Appeal affirming the judgment of Mr. Justice Kekewich ought to be reversed.

Mr. GRAHAM followed on the same side.

Sir H. DAVEY, in opposing the appeal, contended that as the appellants by their provisional specification indicated the nature of their alleged invention to be a method whereby secondary currents could be obtained from an unlimited number of secondary generators without the primary current being anywise affected thereby, the invention claimed was an impossibility, as it would amount to the obtaining of perpetual motion. By the provisional specification the inventors alleged that their invention consisted in the "employment of an alternating current produced by an electro-dynamo machine, and determining by its passage through an unlimited number of induction coils of special construction the creation of induced currents, whose quality and value depended solely upon the construction of the said induction coils;" and by the complete specification this statement was substantially repeated, and although the latter spoke of the secondary generator to be used as being of special construction, there was no statement or indication in it as to the peculiarities of the alleged special construction, the dimensions of two induction coils of ordinary construction, and possessing no novelty, being mentioned. The claims in the complete specification were:—(1) "the privilege of exclusively working our process of distribution, characterised by the following point, as above explained. The employment of an alternating current of high tension for the generation on an unlimited number of secondary generators of induced currents individually utilised either for the production of light or motive power; (2) the system of electric distribution such as is laid down in the foregoing statement; (3) the special construction as described of secondary generators designed to produce this result." The respondent, however, submitted that the proper interpretation of such claims was that the invention thereby claimed was that of a system whereby secondary currents could be obtained from the primary current without the primary current being modified thereby, so that they could be obtained in unlimited numbers without any corresponding expenditure of power on the primary circuit, and that it was to such an invention alone that the patentees could be entitled under the said claims. Immediately before the date at which the hearing of the said petition would have taken place, the patentees applied for leave to amend their specification and claims, and obtained leave to file a disclaimer by which they struck out of the complete specification all the matter relating to the passage of an alternating current through an unlimited number of induction coils, or the creation of induced currents whose quality and value depended solely upon the construction of the induction coils, or as to forming secondary currents without the primary current being anywise affected thereby. As thus altered, the specification described merely a system of distribution of electricity by means of secondary generators, not purporting to be a mode whereby any number of secondary generators could be worked without loss of power, which was substantially the invention described in the provisional specification. Such alteration made the complete specification, as amended, claim an invention wholly different from that referred to in the provisional specification, and for which the patent was granted. By such disclaimer also the third claim, referring to secondary generators of an alleged special construction, was struck out. The chief witness for the patentees was Dr. John Hopkinson, who, in his evidence, admitted that the invention claimed in the claiming clause was not novel, if it was understood to apply to all secondary generators, and he admitted that the specification did not define or give the differentia of that class, or enable the public to ascertain what generators were or were not within such class; also that it was likely the patentees did not themselves know what was and what was not essential to success. The interpretation of the claims put forward on behalf of the appellants varied at different times during the hearing of the case before Mr. Justice Kekewich to the arguments on the appeal. At one time it was contended that an essential of the invention was that the tension in the secondary circuits should be lower than that of the primary; but it was proved by the admission of the witnesses for the patentees and by the evidence of Sir Wm. Thomson and the other witnesses for the petitioners, that no statement to that effect was to be found either in the claims or in the specification. The attention of Dr. Hopkinson was called in cross-examination to various prior publications referred to in the particulars of objection, and amongst them to the account of Jablochkoff's system of electrical distribution set forth in his specification, No. 1,996 of 1887, and in Du Moncel's book. The witness admitted that this described the employment of an alternating current for the generation of a number of secondary generators, and induced currents individually utilised for the production of light, and that if a person wanted to use the alleged invention of the patentees in connection with lamps of the kind described in the publication referred to, he would have to use generators similar to those used by Jablochkoff. Other anticipations were also put to Dr. Hopkinson, in all of which he admitted that there was a distribution of electricity by alternating currents and secondary generators. The distinctions he drew between such proposals and that of the patentees turned chiefly on questions of disadvantage in the special forms of secondary generators described in such anticipations, leading to more or less want of economy in the result; but he admitted that there was no novelty in the secondary generators described in the patent, and that they were no more economical or more suitable for the purpose of distribution than secondary generators of ordinary construction in use at the time, and that it was common knowledge to adopt such generators to produce any desired tension in the secondary circuits. The principal witness called on behalf of the petitioner was Sir W. Thomson. He gave evidence to a like effect with Dr. Hopkinson on the point that the specification gave no description of any special kind of generator to which the invention was limited, and further, that the generators described possessed no novel or patentable features, and did not differ from ordinary generators well known at the time. He further gave evidence that the system of distribution claimed was not novel, but that the anticipations set out in the particulars of objection, that more particularly of Jablochkoff, Edwards and Normanby, and Imray, completely anticipated the alleged invention of the patentees. Mr. Justice Kekewich ordered the revocation of the patent; and in the Court of Appeal, Lords Justices Cotton, Lindley, and Lopes, affirmed that decision. He (the learned counsel) submitted that the alleged invention in respect of which the letters patent were granted, was an invention never in fact made by the patentees, but was an impossibility; that the complete specification, as finally amended, described and claimed an alleged invention larger than, and different from, that originally claimed by the patentees, and for which the patent was originally granted; that the patentees failed to inform the public in their complete specification in what their alleged invention consisted, and how the same was to be performed, and had not enabled the public to ascertain what was the invention claimed by them, or how the same was to be carried into effect; that the alleged invention was not novel; that if the alleged invention was to be held to be restricted in any of the modes contended for at various times on behalf of the appellants, such restrictions did not constitute good subject matter for a patent, and did not constitute a patentable invention, and that, therefore, the appeal ought to be dismissed.

At the conclusion of the arguments,

Their LORDSHIPS said they were of opinion that the decisions of the Courts below were correct; and, therefore, they dismissed the appeal, with costs.

Judgment below affirmed, and appeal dismissed, with costs, accordingly.

Edison and Swan Company and Others v. Bayley Bros.

In the High Court of Justice (Chancery Division) on the 26th inst., the case of the Edison and Swan Company v. Bayley Bros. was before Mr. Justice Stirling.

Mr. ASTON said that it had now been arranged between the parties that the defendants should submit to a perpetual injunction, pay the costs, and take a licence.

Mr. LEVETT: I appear for the defendants, my lord, and I cannot say that the particulars are unreasonable.

Mr. Justice STIRLING: Very well, then; take it by consent.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 18, 1890.

Patent Litigation.—A legal difficulty seems to have arisen between the Thomson-Houston and Westinghouse Companies. The former, as controlling the Brush interests, have brought a suit against the Westinghouse Company for using the double carbon arc lamp, which is protected by the Brush patents. The Westinghouse Company, by way of returning the compliment, have instituted proceedings against the Thomson-Houston Company for employing the overhead construction for electric railroads, said to be controlled by a patent owned by the Westinghouse Company, and also for using the carbon brush, infringing the Forbes patent. What will be the outcome of this group of suits cannot now be predicted; but, if the Westinghouse Company presses the claims above mentioned, there is likely to be some trouble in electric railroad circles.

The Gas Commission.—There is the usual difficulty between the electric lighting companies and the Gas Commission in New

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York city. The bids for city lighting, made by the companies some months ago, were, it will be remembered, refused, and new bids were called for. These have been now received, and prove to be substantially identical with the old bids; consequently, the Gas Commission makes the customary threats of going back to gas lighting.

The Westinghouse Electric Railway Company.—This new Company is rapidly getting ready for operations. One or two of its cars have been run in an experimental way for some little time past. The motors are said to be particularly well designed mechanically, and the running gear of the cars contains various important improvements. The whole system will doubtless be made public in a short time.

Tramways with Accumulators.—Two new systems have been brought to the public attention, each of them embodying some special design in motors and driving gear, but neither having made radical improvements in the matter of batteries. The United Electric Traction Company has done a little towards increasing the use of storage battery cars on the surface roads; and while there is a good deal of experimental activity, so far as the public is concerned, the matter seems to be at a standstill. The overhead system, of course, never can find its way into New York City, and indeed provokes a good deal of unfavourable comment wherever it has been tried in very populous districts, although the popular apprehension of it is entirely out of proportion with the real danger. Several other storage systems are in process of development, and among them all it is possible that this city may see something done towards surface rapid transit; but, meanwhile, some of the lines will probably be cabled, which means delaying the use of electricity for a considerable time, so far as that part of the city is concerned.

CORRESPONDENCE.

PROVING OHM'S LAW.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I regret that while making his useful suggestion calling attention to the fact that in iron and bismuth the resistance *must* be a function of the current, because of the effect of cross magnetism on their conductivity, Professor Silvanus Thompson should have gone out of his way to raise that wretched ghost of a student's difficulty concerning the statement of Ohm's law. To begin by defining resistance, and then to call "$C = \frac{E}{R}$" Ohm's law, is ridiculous, and worthy only of an archaic type of text book.

I had hoped that all chief teachers nowadays taught the law as follows:—That in a given conductor in a given state, the rates of the resultant E.M.F. acting in it, the current thereby produced is constant, however much the intensity of the current be varied; in other words, calling the ratio "resistance," that resistance is not a function of current intensity.

OLIVER J. LODGE.

LEAKS ON ELECTRIC LIGHT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice that in your issue of the 11th you ask for any evidence of charring from leaks in wooden casing of electric light wires.

A case occurred in an installation temporarily under my care about three years ago. I traced a leak on some branch wires to a place where the cable was laid in deal boxing, and then laid in concrete, 6in. deep.

On cutting the concrete away I found the boxing saturated with water, and at a place where the boxing dipped an inch quite a pool of water collected. Just by this pool, but not quite in it, was a very badly insulated joint or negative pole, covered with india-rubber tape, but not jointed watertight.

Both the lid of the boxing and the insulation of the cable were charred away considerably, and the whole thing was hot when taken up. There was another leak on another main of the other pole.

The curious thing to me was the fact that the wood had evidently been a sponge to the concrete moisture, and absorbed all water near enough to be taken up, and then, owing to the concrete setting, had to retain it.

I enclose name of place and contractors, which you will see are both well known. I must ask you, however, to treat these names as confidential.—Yours, &c., J. SAYERS.

Telegraph Department, Midland Railway,
Derby, July 26, 1890.

FIRE OFFICE RULES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. John Verity's letter *re* the installing of houses for electric light appears at a time when the necessity for uniformity of opinion as regards the fundamental points of importance in regard to this subject must be manifest to all those connected with electric light work.

There can be no doubt that differences of opinion as to the best ways of carrying out certain works must exist, as works have to be carried out under circumstances which vary with the numberless conditions obtaining in the individual cases, and it is the duty of the consulting engineer to specify under what circumstances and conditions the quality of the work should be increased or may be diminished and to what extent.

It is evident that Mr. Verity's letter bears upon another matter which requires consideration, namely, on the question of the real position of a consulting engineer, and in how far—if at all—he may be commercially interested in the work on which he advises and which he undertakes to superintend; but leaving this matter for the present out of consideration, it must be evident that there are right ways and wrong ways of wiring houses; this has been amply verified by experience of successes and of failures, and there can surely be no doubt at the present moment in the mind of any intelligent and unbiassed engineer as to what constitutes a safe installation for electric lighting.

Engineers are hampered in their specifications and contractors are worried beyond all endurance by the thousand and one petty differences of opinions existing among the inspectors of the various fire offices. The first attribute of a specification should be its definiteness; but under existing circumstances it is impossible for any engineer to draw up a specification without the introduction of some saving clause which shall provide for the fads of the various inspectors whose opinions on points of quite secondary importance have to be consulted.

I can only say in conclusion, that I trust Mr. Verity's letter may be the means of rousing such discussion of the relative merit of the various clauses in the existing fire rules as to lead to the adoption of a set of rules dealing with the main points of importance in the matter, and thus reducing this vexed question to a matter of comparative simplicity.—Yours, &c.,

ED. C. DE SEGUNDO.

Westminster Chambers, 7, Victoria-street, Westminster, S.W.,
London, 25th July, 1890.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The Metropolitan Asylums Board invite tenders for the establishment of telephonic communication between the Schools and Pavilions for Imbeciles at Darenth, near Dartford. Full particulars may be obtained, and plan inspected, at the chief offices of the Board, Norfolk House, Norfolk-street, Strand, W.C., where sealed tenders, addressed to Mr. W. F. Jebb, clerk, and endorsed "Tender for the Establishment of Telephonic Communication at Darenth," are to be delivered by August 25th.

THE LIGHTING OF DUNDALK.—We are informed that none of the tenders received for the public lighting of Dundalk have been accepted.

MESSRS. SWINBURNE AND CO.—Messrs. Swinburne and Co. announce that they have completed the extension of their works

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and machinery at Teddington, and that they can now guarantee the prompt delivery of Hedgehog Transformers. They also direct attention to their revised price lists.

THE PLANET ELECTRICAL ENGINEERING COMPANY.—This Company intimate that they require agents for their arc lamps in all the important towns of Great Britain.

PARTNERSHIP DISSOLVED.—The partnership between William David Ramsay and Cecil Walker, carrying on business as electrical engineers at 1, Princes-mansions, Victoria-street, Westminster, S.W., has been dissolved.

ST. MORITZBAD.—Messrs. Ganz and Co. will supply the alternators and transformers for the central station at this town.

ALLGEMEINE ELEKTRICITÄTS GESELLSCHAFT.—The *Elektrotechnischer Anzeiger* announces that this Company has decided on the purchase of shares in the Deutsche Lokal und Strassenbahn Gesellschaft to the value of 1,400,000 marks (£70,000), in order to be in a position to devote more energy to the introduction of electric traction.

MESSRS. MULLER AND EINBECK.—These well-known makers of the Tudor Accumulator at Hagen, Westphalia, have just turned their firm into a company, under the title of "Akkumulatorenfabrik Aktiengesellschaft," with a capital of 4½ million marks.

COMPANIES' MEETINGS & REPORTS.

The Direct United States' Cable Company (Limited).

The twenty-sixth ordinary general meeting of this Company was held at Winchester House, Old Broad-street., on July 25th, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. T. Finnis) read the notice convening the meeting and the minutes of the previous meeting, which were approved and signed as correctly entered.

The Directors' report and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—I beg now to move the following resolution before I make the remarks which I usually do at these meetings:—

"*That the report of the Directors, dated July* 11, 1890, *together with the statement of accounts to June* 30, 1890, *annexed thereto, be, and the same are, hereby received and adopted, and that a final dividend be now declared of 3s. 6d. per share, free of income tax, making, with the interim dividends already paid a total dividend of 3½ per cent. for the year ended June* 30, 1890."

Before I ask you to approve of this resolution I shall, as usual, give you some particulars of the working of the Company's system during the last six months. The revenue for the half-year to 30th June, after deducting outpayments, amounted to £40,017 and the working and other expenses, including income-tax, but exclusive of cost of repairs, absorbed £17,616, leaving a balance of £22,401 as the net profit of the half-year, making with £8,318 brought from the previous half-year, a total of £30,719 which has been appropriated as follows:—Interim dividend of 3s. 6d. per share for the quarter to 31st March £10,624. 5s., proposed final dividend of 3s. 6d. per share for the quarter to 30th June £10,624. 5s., transferred to reserve fund account £8,502, balance proposed to be carried forward £968; total, £30,719. The revenue during the earlier portion of the half-year showed some falling off as compared with that of the corresponding period (the tariff being 1s. in each period), but in the later months an increase took place which more than recouped the previous falling off, the result on the whole showing a small increase of £390. The expenses in London, as shown by Abstract "A" in the accounts, remain practically the same as in 1889, with the one exception of stationery and advertising, which shows an increase of £67, due to extra tariffs and other stationery used in the competition for business. The expenses at Stations, as shown by Abstract "B" are on the whole £1,345 higher than those of the corresponding period of the previous year. This increase, as explained in paragraph 6 of the Directors' report, is due to the fact that the expenses of the Chief Office at New York (formerly a joint office) have now to be paid entirely by this Company. Looking to the active competition now going on in New York, the maintenance of an independent office by this Company in that City is considered important. A new station opened by the Company at Glasgow has been working since February last. The aggregate expenses which, but for the facts above mentioned, would have shown a reduction, are on the whole £940 higher than those of the corresponding period of the previous year. The reserve fund after being debited with £4,919 for cost of repairs, and credited with £4,390 for interest, &c., on the investments, and £8,502 transferred from the revenue accounts now amounts to £250,000. The investments, as heretofore, continue to be worth much more than the figure of cost at which they stand in the balance sheet. It will be in your recollection, gentlemen, that at the last half-yearly meeting I gave you a very full exposition of the position of the Company. I then stated that six months hence I feared it would be necessary to draw special attention to our reserve fund. We had been, during the active competition, drawing upon that reserve fund to some extent to supplement our dividends and to maintain the 3½ per cent. which we should otherwise have been unable to pay at the 6d. tariff. I now find, however, that it will not be necessary for me to appeal in any way to the shareholders to-day as to our reserve fund. It seems to me that we have turned the corner. We have for the first time during the last two or three years been adding to instead of taking from the reserve fund. We have increased it now to a very nice round sum; but still I hope, adopting the principle which we have laid down of putting the interest to the reserve fund, and such a sum as we can conveniently spare from our income, that we should continue to increase that reserve fund so as to place ourselves in a thoroughly independent position. I believe our cable stands at a cost very much lower than that of any other cable in the Atlantic at the present time; and when we take into consideration our large reserve fund, I think there is no company which can compare with us as to the value of our property because we consider that our cable, which stands at a comparatively small price to-day, is just as good as any that lies in the Atlantic at the present time, and the others stand at two or three times a higher price than ours. Our cable is now in good working order—so good, in fact, that we are able to work the duplex system by it. In other words, it gives us practically the advantage of two cables; and I am very pleased to say that we are doing our full share of the pool traffic over the Atlantic at the present time. I am bound to say that, working as the "pool" does now, there is an impression abroad that a single cable is a very dangerous investment. But when I tell the shareholders of the Direct Company that ours is one of seven cables in the Atlantic you will feel that your position is a safe one. If our cable were broken for twelve months it would not interfere in the least degree with our income, and the other cables are quite equal to carrying the traffic. If our cable were broken for two years we would still have an income, and if it were broken for three years we would still have a small income. Therefore I wish it to be understood, as many appear to have forgotten the fact, that though we stand as a single cable, we are guaranteed by six other cables. That is a very strong position which we occupy, and taking that in connection with our reserve fund I look on the Direct Company as possessing now the cheapest cable in the Atlantic. We had broken cables the other day, and it is very difficult to effect repairs under £5,000; but we find that these breaks have not taken place from any real decay of the cable, but have arisen from the anchors of fishing boats. The fishermen drop their anchors when fishing and when they take them up again they sometimes pick up our cable. We have done all we can to induce them to drop it when they pick it up, having even undertaken to provide them with new gear if they do so. We have found a feeling of justice towards us at the hands of the fishermen, who have also shown a disposition to save us from any unnecessary expense. I am pleased to be able to make this statement about our cable because people have said to me, "But your cable is only a single cable; it is no good." However, as I have just said, if we have a single cable we are guaranteed by six others. There is another thing in regard to our policy. When we have had a break, we have never hesitated, whatever the weather was, to send out a ship to make the repairs and we have been singularly fortunate in having our repairs promptly executed. We consider that it is a duty to the joint purse—to the "pool" in which we are taking part—to do as fully and fairly our share of the work as we can, and I believe at the present moment we are doing our fair proportion of it. I think it is encouraging, though it is not so encouraging as I should desire, that at the present moment at the 1s. tariff we are carrying quite as many messages as we did at the 6d. tariff. But still, we are not getting that amount of money which such a property is entitled to; and therefore I still hope that something will occur, either by effecting economies through our instruments or our working combination, by which we may see our dividend larger than it is now; but the real point is that, at the present moment, there are more cables in the Atlantic than are required for the existing traffic. We must try, however, to work it out in some way or another—I am not just now prepared to say how—but I say this that this submarine system of telegraphy is a magnificent property. It has become a necessity for the world to have these cables efficiently and properly worked; and I think it would be a reflection upon all concerned if we did not manage in some way to give a fair return to our shareholders, for what has become a great commercial and political necessity. These are my own private views on the subject; and as long as I am connected with the submarine telegraph system I shall always bear in mind, that while we are doing the public a very great benefit, we must be just as well as generous, and must look to our shareholders at the same time. I may say that the position of the "pool" is probably stronger now than it has been for a considerable time. Mr. Ford and myself have just lately been attending the telegraph conference in Paris, and I am very pleased to say that while our cables did not come very much under consideration, the little that did was fairly considered by the other companies, and settled upon a basis which I think ought to be satisfactory to all parties concerned. The interests of the Company were very carefully attended to; and when I tell you that the results were very satisfactory to your Board, you will understand that we have lost nothing by the Conference. I think, gentlemen, these are pretty much all the remarks I have to make to-day, and I will close them by saying that I should be better pleased if we could pay you the old 5 per cent. instead of the 3½ per cent. which we offer you to-day; and if it is possible to work the concern up to that figure, I think you may depend upon your Board giving it every consideration in their power. I now beg to propose the resolution which I have already read to you.

Mr. WM. FORD seconded the resolution, which was carried unanimously.

The CHAIRMAN moved and Mr. FORD seconded the next resolution as follows:—

"*That Mr. Charles Meara be, and he is hereby, re-elected a Director of this Company.*"

The resolution was carried unanimously.

On the motion of the CHAIRMAN, seconded by Admiral R. C. MAYNE, C.B., M.P., the following resolution was carried unanimously:—

"*That Mr. Emmanuel Maguire Underdown, Q.C., be, and he is hereby, re-elected a Director of this Company.*"

Mr. W. J. DEY proposed and Mr. GRIFFITH seconded the next resolution, as follows:—

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"*That Messrs. John George Griffiths, F.C.A., and John Sawyer, F.C.A., be, and they are hereby, re-elected Auditors of this Company for the ensuing year, at a remuneration of* £50 *each.*"

The motion having been agreed to *nem. con.*,

The CHAIRMAN said: That concludes the business of the meeting. I think we may be considered in a very satisfactory state by our shareholders, seeing that we have such a small attendance—I think the smallest attendance I ever remember at a meeting of this Company.

Mr. GRIFFITH proposed a vote of thanks to the Chairman and Directors, and made a touching allusion to the death of Lady Pender, who, he said, was beloved by all who knew her.

Mr. JACKSON seconded the motion, which was carried unanimously.

The CHAIRMAN briefly acknowledged the vote, and the proceedings terminated.

Globe Telegraph and Trust Company (Limited).

The seventeenth ordinary general meeting of the Globe Telegraph and Trust Company (Limited) was held on Tuesday last at Winchester House, 50, Old Broad-street, E.C., under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. W. Payton) read the notice convening the meeting, and the minutes of the previous meeting.

The report of the Directors was taken as read.

The CHAIRMAN: Before asking you to approve of the report, I will, as usual, make a few remarks. The report, as you will observe, is very full. It gives the history of the transactions of the Company during the past year, and contains a tabulated statement of our investments, their cost, and the return on their cost, and the exact amount of the dividend received. In looking over the remarks I made when I had the pleasure of addressing you a year go, I find that were I to repeat them to-day they would be quite appropriate to our proceedings now. I indicated then that there was a considerable amount of prosperity prevailing in the submarine telegraph system generally. We had terminated our battle in the Atlantic, and we found that we were receiving as many messages at the 1s. tariff as we had previously been receiving at the 6d. rate. That was all very satisfactory, and contributed, of course, materially to our exchequer, and eventually, as I shall show you to-day, to our dividend. During the last three years we have been steadily progressing; but, as you know, we progress just as the submarine companies progress, and to-day we are, upon the whole, in a very satisfactory position; and we propose to pay you, as I foreshadowed at the last meeting, a net dividend of 5 per cent. upon the ordinary shares, against £4. 12s. 6d. per cent. which we paid on the last occasion. We have received during the last financial year £198,466. After deducting working expenses we have a balance of £193,499, of which we have distributed £130,806, leaving an available balance for our final dividend of £64,700 to-day. We therefore recommend a dividend of 3s. on the Preference shares and 4s. 3d. on the ordinary shares, which gives 5 per cent. on the latter as against £4 12s. 6d. per cent. paid last year. This, I think, will be satisfactory to the body of our shareholders. We shall carry a small balance forward, but this being a Trust Company we are not intending to put any large amount to reserve. If we take the combined dividends of the Preference and ordinary shares during the seventeen years of the existence of this Company, we find that we have paid an average dividend of £4. 6s. per cent. The dividend we pay to-day makes 5 per cent. for the year, which is a gratifying circumstance, and we hope we may retain the level which this year has given us. With respect to the Companies in which we are largely interested, such as the Eastern and Eastern Extension, it may be said that the result of the Paris Conference has not been unfavourable as regards our Company. I may mention that the policy of these Companies is a very broad one. Their object is not only to do their work well, but to satisfy their customers and the general telegraphing public. Telegraphs have become a great necessity—in fact, the world could not now go on without them, and as we are the head of that great system, it is our business and duty to do our work in such a way that no fault can be found with us. You have read a great deal about the Imperial British East African Company. They had a meeting the other day in London, at which they gave an idea of what they are doing. Unfortunately, they overlooked saying that the Eastern Company at their own cost had laid down a cable to connect their important port of Mombassa with the more important port of Zanzibar. That was done entirely at the cost of the Eastern Company and entirely in the interests of the East African Company. As I have said before, the policy of these submarine Companies has generally been to follow the flag—to follow the trade, and wherever we find trade and civilisation we go alongside of them so as to help them. Gentlemen, the changes in the past half-year have been very few, and the Conference at Paris will not, I think, in any material way disturb the existing state of things. One of the Companies—the Eastern Extension—has entered into an arrangement with the Australian Governments to make a very bold and a very grand experiment—that is, to reduce the tariff from 9s. 4d. to 4s. That is done by the Governments of the Colonies guaranteeing the Companies 50 per cent. of any loss that may accrue. The Directors of these Companies are so confident that the reduced rate will double the traffic that they have not hesitated in taking their part of the risk. I mention that in confirmation of the former remark I made that the policy of these Companies is broad, and the broader it is the more prosperous it seems to me they will be; and as we in this Company are dependent on the success and prosperity of these companies, I think we may look on with perfect confidence that what they do will materially benefit the Globe Company. The changes in our investments last year were very few. We acquired 350 more shares in the American Cable Company, which are guaranteed by the Western Union, and we have acquired them at a price which gives a good return. The shares are guaranteed by the Company for 50 years, and after that period they are to return the cable in as good order as when they took it in hand. I only wish that I might be alive to see the cable that is taken over. The German Government have taken over all the interest in the German Union shares which have disappeared from our statement of assets. There only remains the German-Norwegian Line, and this no doubt will ultimately be acquired by the German Government. I think altogether it would require a little ingenuity on my part to make any statement of sufficient importance to extend my speech. I have given you, I hope, in a few words, evidence that everything is going on as satisfactorily as possible, and I hope, if I have the pleasure and the honour of meeting you next year, that I shall be able to show you that the progress which has been made since last year still continues. Before I close my remarks I wish to allude to the loss of one of our Directors, Sir Daniel Gooch. He was a man well-known in public life as an able administrator, and one in whom the public generally had confidence. In losing Sir Daniel Gooch we have lost a wise counsellor, and I desire publicly to express our regret at that loss. The world moves, changes are continually taking place, and somehow or other men come in to take the places of those who have gone before. I hope the undertaking, when well established, will continue to prosper even when those who projected it have passed away. I now beg to move:—

"*That the report and accounts for the year ended July* 18, 1890, *submitted to this meeting be, and they are hereby, received and adopted, and that a dividend be now declared, payable on and after this date, of 3s. per share on the Preference shares, less tax; and of 4s. 3d. per share on the ordinary shares, income tax having already been deducted, making, with previous payments, a total dividend for the year of* 6 *per cent. on the Preference shares, less income tax, and of* 5 *per cent. net on the ordinary shares.*"

The MARQUIS of TWEEDDALE seconded the motion, which was agreed to unanimously without discussion.

In answer to Dr. POCOCK,

The CHAIRMAN said: The East African Company have their headquarters at Mombassa, about 140 miles from Zanzibar. They are making that an important post; and the Eastern Company, over which I preside, thought that the best way they could help on that great enterprise and the development of Africa, was by laying down a cable from Zanzibar to Mombassa. That we did entirely at the cost of the Eastern Company, and we trust that the traffic will be such as to repay us for the outlay. At all events, we have done that which we considered it our duty to do—to follow the flag and to encourage as far as lay in our power the development of the country. We have found in the past that telegraphs have played an important part, and we shall continue the policy we have pursued whenever we can do it with effect. He then proposed the re-election of Mr. William Ford as a Director of the Company.

Sir JAMES ANDERSON seconded the resolution, which was carried unanimously.

The CHAIRMAN then proposed the re-election of Sir Henry Daniel Gooch, Bart., as a Director, observing that that gentleman was a son of the late Sir Daniel. The Directors thought that whenever there was evidence of ability, and where the father had done good work, it was proper that the son should succeed to his position.

The MARQUIS of TWEEDDALE seconded the resolution, which was carried unanimously.

On the motion of a SHAREHOLDER, seconded by Dr. POCOCK, the auditors, Mr. John George Griffiths, F.C.A. (of the firm of Messrs. Deloitte, Dever, Griffiths, and Co.), and Mr. Wm. Griffith, B.A., were re-elected auditors of the Company.

Mr. WILLIAM GRIFFITH said that he felt very grateful for this renewed vote and this expression of their confidence. It was not only a duty but a pleasure to audit the books of the Company. The book-keeping was excellent. They had not merely examined the books but the vouchers as well, and had looked at the securities, which were all found safe. He thought they might not only congratulate themselves on the larger dividend that had been declared, but on the future which Sir John Pender hoped would come to them, and of which they had every assurance. The present was one of the largest dividends they had ever received, and must be a cause of congratulation. But while they congratulated themselves on this success he thought they must agree with the early remarks of Sir John Pender in reference to the loss they had sustained by the death of one of their old Directors—one who had been connected with them for so many years—Sir Daniel Gooch, who had the confidence of every one who knew him. He (Mr. Griffith) had met him frequently at the meetings of the Great Western Company, and in all respects he was a man of mark. He hoped that the Chairman's remarks in reference to the successor to Sir Daniel Gooch, who had been elected to-day, would be realised; but while touching on this subject, they ought to remember that they had not only lost one of their Directors, but that one of the Directors had had his home darkened by the loss of an admirable and estimable wife—one who shed a glamour over his home, who administered its hospitality, and who was admired not only for her hospitality, but also for the advice which she was in the habit of giving to her very able husband, Sir John Pender, who, he hoped, would excuse him for making these remarks on such an occasion. It was true that his home had been darkened, but they knew that there was a brighter home above, whose foundations were indestructible, whose happiness was without alloy, and whose duration was not merely temporary. He thought they would agree with him that they ought not only to express their gratitude to Sir John Pender for his able administration of the Company's affairs, but their sincere regret at the loss which he had sustained.

Mr. JOHN NEWTON, in seconding the resolution, said he did not think it was an occasion when they could say many words, but what the previous speaker had observed so truly represented the sympathetic feeling of the shareholders in the Globe Company for Sir John Pender that he felt sure it would receive the support of the meeting.

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The CHAIRMAN: Ladies and gentlemen,—It is a very pleasant state of things between Directors and a body of shareholders when, after 17 years' experience and trial, those shareholders are able to express the kind and warm sympathy which you have done to-day. I think it is an evidence that, apart from the general conduct of affairs, which has secured for the Board your confidence, there is something beyond that circumstance when we secure from you your sympathy. I thank Mr. Griffith most warmly for the kind way in which this vote has been proposed by him, and I also thank Mr. Newton for the very sympathetic manner in which he has seconded it, as well as the shareholders for the cordial way in which it has been received. Mr. Newton, I believe, has attended almost every meeting out of the 17 which we have held, and he has seen the progress of this concern, and more or less taken a part in it. We are to-day a very sympathetic body of shareholders and Directors, and I thank you very much for your kind expressions.

The proceedings then terminated.

The Telephone Company of Austria (Limited).

The seventh ordinary general meeting of this Company was held yesterday at the offices, 53, New Broad-street, under the presidency of Mr. Henry Grewing.

The SECRETARY (Mr. Richard Rodgers) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—I have very little to add on this occasion to the observations which are contained in the report which has been issued, as the Company has been progressing very satisfactorily during the last financial year. The increase, as you will have noticed, amounts to rather more than it did at the corresponding period of the previous twelve months, when it was 20,749 florins, it being now 27,450 florins. Since the date of our financial year to 31st of March, a satisfactory increase has taken place, amounting to about 17,430 florins, which, of course, will appear in the next accounts. I have to congratulate the shareholders on the fact that this is the first year since the existence of the Company that we have been in a position to declare a dividend on the ordinary shares, 2½ per cent. having been paid already and 1½ per cent. being proposed to be added to that, making a total of 4 per cent. for the year. It was not that we had no profits to apply to dividend on previous occasions; but, as you are all aware, the demands on capital have been so pressing that it was not so easy for us to satisfy capital account requirements. We had, therefore, to invest surplus profits in the extension of the business, and there is no doubt that we shall now begin to reap the benfit of this policy. I may say that the Consolidated Company have made certain arrangements by which they are prepared to supply us with any reasonable amount of capital so long as we can show that it is judiciously invested. Both as regards revenue and net profits, our permanent prosperity depends on a continuation of our concessions with the Austrian Government. They will expire between this and 1893; and we are now in negotiation with the Government for a prolongation of them on the basis of certain understandings which were arrived at between ourselves and the Minister of Commerce as to the time of the prolongation or the purchase. We have no doubt that it will be a satisfactory arrangement for the future stability of the Company. The Chairman concluded by moving the adoption of the report and accounts and the declaration of the dividend recommended.

Mr. C. L. W. FITZGERALD seconded the resolution, which was carried unanimously.

The retiring Director, Mr. R. E. Bateman, was re-elected to his seat at the Board; and the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., having been reappointed, the proceedings terminated.

The Edison-Swan United Electric Light Company (Limited).

The seventh annual ordinary general meeting of the shareholders of this Company was held on Monday at the Cannon-street Hotel; Mr. James Staats Forbes presiding.

The SECRETARY and MANAGER (Major S. Flood Page) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said that the report was one of the most embarrassing he had ever had to deal with—it did not want any apology. In fact, he was scarcely at home with this sort of thing, particularly in the Edison and Swan Company, because they were old enough to remember when the meetings were not of the present character, and the results were not quite so satisfactory. However, they would take it for what is was worth, and as good wine needed no bush he would have very little to say about it. The report itself was so exceedingly brief as to indicate that there was not much to be said. The facts were to be found chiefly in the figures, in connection with which the important fact was the profit and loss account, and the chief feature of that was that the balance carried to the credit of that account, after making every fair and proper charge against it for the working expenses of the undertaking and for the due depreciation of plant, &c., presented the respectable balance of £61,115, enabling the Company to divide, on the recommendation of the Directors, if the shareholders should see fit to approve it, the full 7 per cent. upon the capital, and a very considerable contribution in respect of those sadly too long years when there was no dividend to pay at all. They all knew that the dividend on the ordinary stock to the extent of 7 per cent. per annum was cumulative—that was to say that, in the years when it was not secured by the profits, any balance was carried forward as a claim on the future. Having waited for a great many years for the happy event, they had been last year able to wipe out some of those arrears, and they would be able to do so in a larger proportion this year. They would see that stock on hand on July 1, 1889, was £25,985. He might remind honourable proprietors that the character of the business demanded a very large amount of capital being locked up in stock. The lamps, as was well known, were of a very great variety of form and power, and many people had different ideas as to what kind they would like, and in order to be ready to supply whatever was wanted they must keep a very large stock on hand in anticipation of the demand. If they would cast their eye to the opposite side of the account—for he might as well exhaust the question of stock at once—they would find that there was a large increase, by the sale of lamps, fittings, &c., from £25,985 to £56,266. He would relieve their minds at once by saying that only a small portion of this increase was attributable to the number of lamps, which had kept pace in almost arithmetical proportion with the number of sales. A large portion of this increase was the price of obtaining platinum, which, with a certain amount of foresight, they had availed themselves of the opportunity of buying at prices which were already considerably exceeded, and that platinum was carried to the account at cost price, and was held in reserve, and would account for £21,000 of the increase. They found that in the market the supply of it did not keep pace with the increased demand, and putting two and two together, they considered that the price might go up, and, therefore, they laid their hands on a considerable amount of it. Wages, purchases, &c., amounted to £73,719; then there was the cost of conducting the business, salaries, Directors' fees, rent, office expenses, &c., £13,915, and depreciation on plant £1,838. On the other side of the account, as he had said, by sale of lamps, fittings, &c., they had realised £61,865, while by interest on investments they had earned £1,442. Stock in hand stood at £56,266. The difference between the sales and interest and the value of the stock, and the value of the stock on the other side, plus the expense of the year's business, left a balance of £61,115. By reference to the accounts it would be seen what they proposed to do with this amount, namely, to pay a dividend for the year ending June 30, 1890, at 7 per cent. per annum (of which £12,371. 14s. 7d. was paid as interim dividend, on February 20, 1890, being £24,743. 9s. 2d.; and also the payment of the balance of cumulative preferential dividend on the "A" shares, for the year ended June 30, 1884, at the rate of 4 per cent., which would amount to £14,139. 2s. 4d.; and payment on account of cumulative preferential dividend on the "A" shares at the rate of 4 per cent. for the year ended June 30, 1885, £14,139. 2s. 4d. This meant that for the year ended June 30th, 1884, they last year paid 3 per cent., which left a balance of 4 per cent. in arrear, and for the following year they now purposed paying 4 per cent. Having done that, they still had £3,093, which they had carried to reserve fund. Coming to the share capital account—or the balance-sheet—there was no substantial alteration. The capital remained exactly as it was in the last account. The only figure which would be affected would be the one under the title of "B" shares, which were entitled to one-fourth of the profits after a cumulative preferential dividend of 7 per cent. per annum had been paid on the "A" shares. The particular part of that entry was that Preferential Cumulative dividend of 7 per cent. amounted on June 30, 1890, to £110,769, which was the balance of the amount still to be wiped off out of future profits. Sundry credit balances and reserve fund amounted respectively to £26,257 and £4,595. On the other side of the account they came to what they got for that capital—by cost of patents, goodwill, preliminary outlay, loss on working, &c., as per last balance-sheet—£235,614, that had been from time to time subjected to diminution by writing down on the realisation of property and so forth. There was a further expenditure thereon during the year of £2,439, making £238,053. As a set off against this, there followed an item—"Less amount realised by sale of plant, &c."—amounting to £2,030, bringing the figure down to £236,022. The amount of "B" shares of the Company issued as *per contra* was £117,820. They knew the history of these shares. They were given to Mr. Edison and his friends as the value of their interest in the concern. Their other assets were: Manchester Edison-Swan Company (Limited), £100,000, "B" shares at nominal cost £12,000; freehold property, £33,306; plant and stock, £77,221; office furniture, £256; debtors, £15,203; investments, £27,500; and cash at bankers and in hand, £31,563. They would see that not an inconsiderable amount of the capital of the Company was in the shape of solid pudding, namely, freehold property, £33,306, which was the property of a going concern, embracing the factory at Ponder's End, which they had bought cheaply, and on which they had spent some money, and which from time to time was being extended in order to meet the very great demand possibly for the lamps in the future. They put its value down at what he thought was a very safe figure. The same might be said of the other investments. Unless they wished him to go into any details he thought it would be wise to end what he had said by commending to them the recommendation of the Board to disburse the proposed dividend, giving them the assurance that in the details of the several amounts a very liberal allowance had been made on all heads on the debit side, and the balance which was brought forward was one which was absolutely without charge upon it which the current revenue ought to bear. He concluded by moving:—

"*That the report and accounts to June* 30, 1890, *be received and adopted.*"

The DEPUTY CHAIRMAN (Mr. F. R. Leyland) seconded the motion, which was carried unanimously.

The CHAIRMAN then proposed, and the DEPUTY CHAIRMAN seconded the next resolution as follows:—

"*That a dividend at the rate of* 7 *per cent. per annum be and is hereby declared on the A shares of the Company for the half year ending* 30*th June,* 1890 (*making* 7 *per cent. for the year*), *and of* 4 *per cent. in completion*

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of payment of arrears of Cumulated Preference Dividend for the year ending 30th June, 1884, and of 4 per cent. in respect of arrears of Cumulative Preference Dividend for the year ended 30th June, 1885; all to be distributed in accordance with the provisions of Clause 87 of the Articles of Association."

On the motion of the CHAIRMAN, seconded by Mr. WILSON, Mr. Shelford Bidwell, F.R.S., was elected to a seat at the Board.

On the motion of Mr. DONOVAN, seconded by Mr. DAY, the Company's auditors, Messrs. Welton, Jones, and Co., were reappointed; and a vote of thanks having been passed to the Chairman and Directors, the proceedings terminated.

Manchester Edison-Swan Company (Limited).

The eighth annual meeting of this Company was held in the Memorial Hall, Albert-square, Manchester, on Monday; Mr. V. K. Armitage, Chairman of the Company, presiding.

In moving the adoption of the report and balance-sheet, the Chairman said they were not as satisfied as they might have been with the result of the year's operations, inasmuch as, instead of making something over 10 per cent., as they did in the previous year, they had only made about 5 per cent. That was owing to no fault of theirs, for they had worked as hard, if not harder, for the 5 per cent. than they did for the 10 per cent.; but the real cause was that all over the country there was a falling off in the demand for small separate installations. Parliament had been issuing provisional orders for central stations broadcast, and people who wished to have the electric light were waiting to see what would be the outcome. The Directors knew a great many cases in which people put in the wires when building their houses or offices, but would not give the order for electric light installations and private plant because they hoped in a short time to be able to draw their supply from a central station in the same way as they now did gas. He believed this was the experience of every electric lighting company. He had not the smallest doubt that when the provisional orders were put into execution the Manchester Edison-Swan Company, with the name they had acquired for doing good work, would get a fair share of the work which he anticipated would have to be done. Since the last meeting Mr. J. R. Williamson had resigned through ill-health, and the Directors had appointed in his place Mr. W. P. James Fawcus, who had special knowledge of central lighting stations. The profit and loss account showed a falling off in the profits and an increase in the expenditure, the latter simply meaning that the more difficulty there had been to get orders the more money and time they had spent in trying to get them.

Mr. ISAAC CREWDSON WATERHOUSE seconded, and the motion was carried.

In answer to a question as to whether it would not be advisable to hold the meetings half-yearly instead of yearly, the CHAIRMAN said he did not think it was necessary.

On the motion of the CHAIRMAN, seconded by Mr. WATERHOUSE, it was agreed to appropriate £1,000 of the year's profit to the payment of dividend at 5 per cent. per annum, and it was also resolved to vote £150 of the balance (£647 6s.) as remuneration for the Directors.

Sir Joseph C. Lee and Mr. I. C. Waterhouse, the retiring Directors, were re-elected, and Messrs. Jones, Crewdson, and Youatt were also re-elected auditors.

A vote of thanks to the Chairman concluded the meeting.

The following is the Report of the Directors for the year ending May 31st referred to above. The net profit, including last year's balance, amounts to £1,647. 6s., which it is proposed to appropriate as follows:—

	£	s.	d.
To payment of dividend at 5 per cent. per annum ...	1,000	0	0
To balance carried forward	647	6	0
	£1,647	6	0

If the above be approved, the dividend warrants will be issued on August 1, 1890. Since the last meeting the Company's Managing Director, Mr. J. R. Williamson, has resigned through ill-health, and the Directors have appointed Mr. W. P. James Fawcus as manager. Two of the Directors, Sir Joseph C. Lee and I. C. Waterhouse, Esq., retire in accordance with the Company's Articles of Association; they are, however, eligible, and offer themselves for re-election.

Elmore's Patent Copper Depositing Company (Limited).

The first annual general meeting of this Company was held on Monday, at Cannon-street Hotel, E.C.; Mr. E. J. Carson presiding.

The SECRETARY (Mr. J. Shurmer) having read the notice convening the meeting,

The CHAIRMAN apologised for the absence of Sir John Morris (the Chairman of the Company) and said:—The Directors are very glad to be able to meet you to-day with what I will venture to call, taken on the whole, an excellent record of progress from the date of the formation of the Company, and substantial results in the shape of profits. The report and accounts which, I suppose, as usual, will be taken as having been read, show that we have made the large sum of £107,111 by the sale of the licence to manufacture wire. After writing off the original estimated value of this licence, and distributing the large amount of £35,000 among the shareholders, we have a balance brought forward from profit and loss account of nearly £40,000; and I venture to think that these are satisfactory results to have been obtained within the short space of time that the Company has been in existence. I am often met out of doors with the question, "Why have you not sooner commenced manufacturing work, and proved the commercial value of your process?" I am not going to excuse this delay, for I think I can justify our policy, and will prove to you that you are indebted for the very large profits which we have earned for you to the policy of the Board in changing the originally selected works at Sheffield, which has been the principal cause of the loss of time. Had we carried out the original intention of erecting our plant and machinery in these buildings, we should no doubt have got to work much quicker, but we soon discovered that our process was capable of very large developments and extensions in different directions, and that we should inevitably require a large amount of land adjoining the works of the original company for the purposes of the sub-companies which we soon foresaw it would be necessary to form, in order to extend our operations, as they will require to be extended. Land suitable for our purposes was not to be had in the neighbourhood of the factory first selected; and as it was of the first importance that any new works which might have to be erected for the extension of the process should be close to the parent company's works, in order that they might be managed under the supervision of the Messrs. Elmore, we set about looking for a more favourable site, which we eventually found in Haigh Park, close to Leeds, as you have already been told. There we have unlimited room for expansion, with the added advantages of cheap fuel and excellent means of communication, both by rail and canal, and at that place we have accordingly erected our works, and found a site for the first of our extensions, viz., the works of the Elmore Wire Company, and without this site we could not have ventured to bring out the Wire Company at the time we did, and with the very satisfactory results in the shape of profits with which you are all acquainted. Those who cavil at what they consider our long delay should consider that we have so thoroughly developed and proved our wire process as to completely gain the confidence of the trade—so much so, indeed, that the Wire Company has already contracted to sell the whole of its possible output of wire spirals for some time to come to a powerful group of Birmingham wire drawers, at prices that will not only show a very handsome profit to the shareholders of that Company, but which will also largely benefit ourselves as the sole owners of the founders' shares. The exhibition of our products, which is now on view in Queen Victoria-street, has proved to the trade that we can manufacture copper tubes on a commercial scale of any diameter, and of a quality that cannot be approached by any other process, with the result that we have not only received many inquiries and large orders for our manufactures, but also negotiations have been set on foot with the object of inducing us to grant licences to the trade to manufacture goods of certain classes for themselves. Here I may remark that there is room for all, and that the policy of your Board will be not to fight with the existing manufacturers, but to work in concert with them. There are plenty of articles which it will pay us well to allow the copper manufacturers to make for themselves by our process; while, on the other hand, there are other articles, such as tubes of large diameter, which it will pay them to hand over to us to manufacture for them. The most serious by far of the difficulties encountered, causing delay, was the failure of the first engine supplied to us. The Board spared neither pains nor expense in regard to the purchase of this engine. The manufacturing firm was one of recognised repute; nevertheless, the results were most unfortunate; and the makers, thoroughly alive to their responsibilities, are now engaged in substituting another new engine for the defective one. Meantime we have two other engines at work, and giving great satisfaction. The greater part of our preparations at Leeds are now completed; all that remains to be done is to finish and fit up the extensions of our depositing sheds. This work is comparatively easy, but we were resolved not to undertake it until we had gained not only practical experience with the first 5-ton a week plant, but also experience as to the requirements of the trade—a most important point, for on these requirements depended to a large extent not only the detailed arrangement, but also the leading dimensions of the large sheds. All this experience we have now gained, and we are proceeding as rapidly as possible with our extensions. As to the future, the Board entertains no feelings but those of confidence. Your sources of profits, as foreshadowed in the prospectus, come under two heads—viz., those derived from the manufacture of the specialties of the Company and those to be derived from the granting of licences to others. From the last of these sources you have already derived a large benefit, and during the current year and afterwards there is every reason to conclude that a very satisfactory income will be derived from granting licences to the large existing copper manufacturers. From the former source the profits are now beginning to accrue, and the results will go on continually increasing with the extension of your works. Your processes have been thoroughly proved, not only in a technical sense, but also commercially, and I therefore consider that we have every reason to look forward confidently to a long career of prosperity. I must not conclude without paying a tribute to the energy, talent, and industry of our works managers (the Messrs. Elmore); they have had an arduous task to accomplish, and have been unremitting in their endeavour to promote the prosperity of the undertaking. I now beg formally to move:—

"*That the Directors' reports and accounts for the period ending June 30th 1890, be received and adopted, and that a dividend of 25 per cent. upon the paid-up capital of the Company be, and the same is hereby, declared payable on the 30th instant.*"

Mr. F. L. RAWSON seconded the motion.

Mr. RUCKER asked whether the estimate given in the prospectus as to the cost of production had been verified, and whether there was a large amount of work offering at remunerative prices.

Mr. HURST wished to know whether the Board had considered the desirability of setting aside some portion of the large profits made last

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year by the sale of their patents to create a reserve fund. It seemed to him that all businesses depending upon industrial inventions were subject to great vicissitudes, and, consequently, it was necessary to strengthen the hands of the Company by retaining for a period some portion of the proceeds which were now in hand. He also thought that the fees and bonus of the Board amounted to a large sum for a small Company like theirs. If part of the profits were set aside for creating a reserve fund, there would not, he said, be the large dividend paid to the shareholders or the large percentage of bonus paid to the Directors.

The CHAIRMAN pointed out that the £20,000, the estimated value of the patent for the manufacture of wire, had been placed to the reserve.

Some other questions having been asked, the CHAIRMAN replied, and then went through the various items in the accounts, concluding by saying:—I am happy to say that the cost of manufacture is considerably less than the estimate of the vendors. We have received a great many large orders, but we have not taken them because they are beyond our means of completing. They exceed the capacity of even our extended works. By refusing these orders do not understand that we are casting them adrift altogether. I think our position is such that we can at any time get any amount of work to keep us in full swing. With regard to the sale of licences and division of profits, we very properly took counsel's opinion on the subject before we acted, and our action is the result of their opinion.

In reply to a Shareholder, Mr. ELMORE said that he believed in six months from now they would be able to pay a dividend by manufacturing. They were actually earning money at the present moment from manufacturing.

After further discussion, Mr. HURST moved as an amendment:—

"*That the accounts be adjusted by the creation of a reserve fund to the extent of* £30,000, *and that the balance remaining thereafter be distributed in the form of a dividend to the shareholders.*"

The amendment having been seconded, was put to the meeting and rejected, and the motion for the adoption of the report carried with three dissentients.

The Board were then re-elected, and the auditors reappointed, after which a vote of thanks was accorded to the Chairman for presiding.

The following is an abstract of the Directors' report, &c., for the period from the date of the Company's formation on January 18, 1889, to June 30, 1890:—

In March last the Board disposed of the exclusive British licence for the manufacture of wire to Elmore's Wire Manufacturing Company (Limited). The shares of this Company (£2 each), were issued at a premium of £1, half of which, in addition to the sum of £75,000, went to our own Company. The issue was made to about 500 applicants. A total sum of £105,000 has been received from the Wire Company, and, in addition, our own Company has a further interest contingent upon the allotment later on of the balance of shares of the first issue. Our own Company holds, also, all the founders' shares, which are entitled to one-half the profits after 20 per cent. has been paid to the shareholders of the Wire Company. The Board regard these founders' shares as a most valuable asset. It may here be stated that the Wire Company have received an offer from a strong group of Birmingham firms to take their whole output of wire spirals at remunerative prices.

The Board recommend that out of the sums above mentioned an immediate distribution be made of 10s. per share, less income tax, which, with the interim dividend of similar amount paid in April last, makes a total distribution equal to 50 per cent. on the paid-up capital for the period named.

The sum of £20,000, being the estimated original value of the patents for the manufacture of wire, has been reserved, and will be invested or employed in the Company's business, as may be deemed most expedient.

A further amount of £4,584. 8s. 3d. is carried forward, after setting aside £35,000 for the second dividend referred to above.

After alluding to the acquisition of a new site for their works, and to the delay in commencing operations through the failure of the engines supplied, the Directors report that everything is proceeding satisfactorily at the works.

Of the 20-ton per week depositing plant, now in process of completion, the first section, capable of turning out five tons a week, has been satisfactorily at work for several weeks. The works are fitted with the electric light throughout, and an ample supply of copper purchased at prices considerably below the present market quotations have been provided.

The demand for the Company's products is far in excess of this 20-ton plant, and the prices obtainable are most remunerative, and the whole of the available plant is engaged in the execution of orders.

Cuba Submarine Telegraph Company (Limited).

Report of the Directors for the half-year ending 30th June, 1890, to be presented at the thirty-eighth ordinary general meeting of shareholders to be held on August 6th, 1890, at 12 noon.

The Directors beg to submit, duly audited, the balance-sheet and accounts for the half-year ended June 30th last. From these it will be seen that the gross receipts (including the balance brought from last account) amount to £23.611. 4s. 4d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable, and the expenses in connection with cable repairs) to £11.209. 12s. 4d., leaving a sum of £12.401. 12s. to the credit of revenue account. Of this the sum of £2.500 has been added to the reserve fund, increasing that fund to £93.500. The dividend on the Preference shares will absorb £3.000, and leave £6.901. 12s., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 8 per cent. per annum, free of income-tax, the balance, £501. 12s., being carried forward to the current half-year's account.

The unusually large sum borne by the revenue of the half-year for repair of cables has been expended upon the Batabano-Cienfuegos Cable, which has been repaired three times, having twice been damaged by ships' traffic, and upon the Cienfuegos-Santiago 1875 Cable, which has been thoroughly repaired. Both these cables are now in good working order.

A contract has been entered into with Messrs. Hooper, of Hooper's Telegraph Works, for the laying of a new cable between Batabano and Cienfuegos, which will be completed in a few months: when this is finished the whole of the Company's cable system will be in duplicate.

No progress appears to have been made by the French Cable Company in its scheme to lay cables along the north coast of Cuba in competition with this Company's cables along the south coast of the island, the Spanish Government having postponed further consideration of the terms of the proposed concession to the French Company until judgment has been given in this Company's action for the protection of its rights—rights which would necessarily be seriously prejudiced by the new scheme if a concession were granted.

The Director who retires from the Board at this time is Mr. Alexander F. Low, who, being eligible, offers himself for re-election. Mr. John Gane, the auditor, also retires, and offers himself for re-election.

Chili Telephone Company (Limited).

Report of the Directors to the shareholders, to be presented to the first ordinary general meeting, to be held at Winchester House, Great Winchester-street, E.C., on Friday, August 8, 1890, at noon.

The whole of the 40,000 shares offered in August last were subscribed for and allotted, and the full sum of £5 has been since received on each share.

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN

PHOSPHOR BRONZE.

PHOSPHOR BRONZE

BEARINGS, BUSHES,

AND OTHER PARTS OF

ELECTRICAL MACHINERY.

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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The purchase money of the properties in Santiago, Valparaiso, Concepcion, Iquique, Chillan, Talcahuano, Talca, Pisagua, Serena, Coquimbo, Tomé, Penco, Coronel and Lota, has not yet been paid in full to the vendors. The transfer of these properties was, in due course, made to this Company by the vendor Company in America; but some shareholders of that Company resident in Chili obtained an injunction to restrain the legal registration of the transfer, with the view apparently to secure to themselves a larger proportion of the vendor Company's assets than would fall to them upon a *pro ratâ* division with the shareholders in America. The action in the Chilian Court is between the vendor Company and a small minority of its shareholders. This Company is not a party to it, but the Board has used, and is using, its best endeavours to remove the impediment to the legalisation of the transfer. Negotiations are reported to be pending to settle the differences by compromise or arbitration; either mode would raise the injunction, and allow registration to be completed.

After much correspondence and considerable loss of time, the vendor Company appointed this Company's General Manager in Chili to be the General Manager of the vendor Company there, and consequently, since that appointment the business has been conducted without serious inconvenience.

The business has been carried on for this Company since May 1, 1889, and the net profit to March 31, 1890 (after providing for the extraordinary depreciation in currency) amounts to £5,520. 8s. 1d. The Directors recommend a dividend of 2s. 6d. per share, being a fraction more than at the rate of 5 per cent. per annum from the time the capital has been received to the 31st March last; this will leave £520. 8s. 1d. to be carried forward to the account of the next year.

The business is progressing satisfactorily.

—	May 1, 1889.	March 31, 1890.	Increase.
The number of subscribers was.....	2,070	2,868	798
The gross revenue was at the rate per annum of	$225,357	$300,346	$74,989
The mileage was	2,523	3,320¾	797¾

The above increases were during eleven months only. The General Manager in Chili has every confidence that, in the current year, very much more favourable results will be shown, and his estimate of improvement is confirmed by a continuous and rapidly-increasing demand for telephones.

Negotiations have lately been opened for the sale to this Company of the property, plant, and business of the National Telephone Company of Chili (National Company Telephonos Chile), in Santiago and Valparaiso, and the Directors have been advised by cablegram of the purchase of the whole for £36,000. That Company was the only competitor with this Company, and the Directors having now, practically, the control of the telephone business in Chili, anticipate that the Company's revenue will be considerably increased; while the requirements of the public will be fully met, by necessary extensions, and moderate and more uniform charges.

In accordance with the Articles of Association, the Hon. F. Ernest Allsopp and Mr. Thomas Greenwood retire from the Board of Directors, but, being eligible, offer themselves for re-election. The Auditor, Mr. Thomas A. Welton, also retires, and offers himself for re-election.

NEW COMPANIES REGISTERED.

EARTHY METALS COMPANY (LIMITED).—Registered with a capital of £2,000 in £50 shares. Objects: To carry out an unregistered agreement with Luis Falero. To produce and prepare for market, sodium, potassium, magnesium, aluminium, and other metals, and to carry on business as metallurgists, manufacturing chemists, and of makers of and dealers in electrical, chemical, and scientific apparatus and materials.

FRANCO-AFRICAN LIGHTING SYNDICATE (LIMITED). — Registered with a capital of £25,000 in £1 shares. Objects: To carry on in Algeria, Tunis, or other part of the French dominions or protectorates, the business of a gas or electric light company in all branches.

PLYMOUTH AND DISTRICT PULSION TELEPHONE COMPANY (LIMITED).—Registered by Sir Joseph Causton and Sons, 9, Eastcheap, E.C., with a capital of £4,600 in £1 shares. Object: To carry on the business of a telephone company, and for such purpose to purchase the patent rights granted to Lemuel Millett for improvements in a mechanical telephone known as the Pulsion telephone.

WOODWARD, GROSVENOR AND COMPANY (LIMITED).—Registered with a capital of £90,000 in £10 shares. Objects: To take over the businesses of Woodward, Grosvenor and Co., and the Stour Vale Mill Company, carried on at Kidderminster and 102, Newgate-street, and to trade as carpet manufacturers, spinners, general merchants, engineers, electricians soap and glue manufacturers, &c.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 25th amounted to £4,750.

BRIGHT PLATINUM PLATING COMPANY (LIMITED).—On the petition of G. Twynam, a judgment creditor, Mr. Justice Stirling, on Saturday, ordered this Company to be wound up.

CHEMICAL CARBON COMPANY (LIMITED).—It has been resolved to wind up this Company; and Messrs. Dowling and Purberry, of Basingstoke, have been appointed liquidators.

EDWIN FOX AND COMPANY (LIMITED), IN LIQUIDATION.—A meeting was called for Wednesday last by the "Committee of Inspection," to take counsel with the creditors of the Company as to the advisability of taking action against the late Directors of the Company. In the circular issued, many grave charges are brought against the late management.

INTERNATIONAL CABLE COMPANY (LIMITED).—The petition of Alfred Sohier Bolton, member of a large firm of wire manufacturers at Cheadle, for the winding up of the International Cable Company (Limited), was again before Mr. Justice Stirling on Saturday; and, after hearing Mr. Buckley, Q.C., on behalf of the Company, his lordship, without calling on Mr. Graham Hastings, Q.C., to reply, made a winding-up order in the usual form.

MUTUAL TELEPHONE COMPANY (LIMITED).—At a meeting of the shareholders of this Company, recently held at Manchester, Mr. A. D. Provand, M.P., in the chair, resolutions were passed increasing the capital from £100,000 to £350,000, in order to allow an extension of the Company's field of operation, and altering the Articles of Association so as to permit interest to be paid up to 10 per cent., instead of 6 per cent.

STOCK EXCHANGE.—Application has been made to the Committee to allow Elmore's Patent Copper Depositing Company (Limited) vendors' shares, to be quoted in the official list.

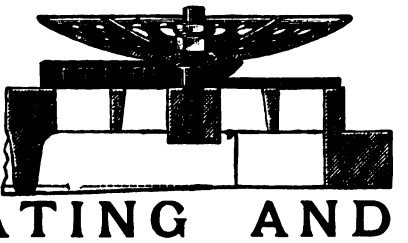
WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—At their meeting on Wednesday the Directors declared an interim dividend of 3s. per share, tax free, in respect of 1890.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 25, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,679.

WESTINGHOUSE ELECTRIC COMPANY.—At a meeting of the stockholders of this Company, recently held at Pittsburg, Pa., it was announced that an increase in the capital stock of not less than $5,000,000 was authorised, each stockholder being entitled to subscribe for one-half share of stock for each share now held by him at $40 per share; and it was stated that Mr. George Westinghouse, jun., had agreed to take a fourth of the new issue on those terms. The central station ordered by the Metropolitan Electric Supply Company (Limited) in London was in operation, and was the most complete and perfect central station in Europe. The English Company formed to work the Westinghouse patents was a great success, and the business abroad bids fair to be a source of great profit to the parent company.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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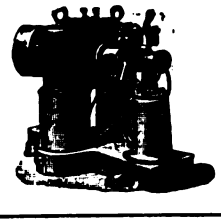
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 23.		Price Wednesday, July 30.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending July 30.	
£								£ s. d.		Highest.	Lowest
			TELEGRAPHS.								
1,381,380	Stock	12/6	Anglo-American	50	51	50	51	5 7 10	Jan., Apr., July, Oct.	50	..
2,809,310	Stock	25/0	Do. Preferred	86	87	86⅛	87½	6 5 9	" "	87½	86⅝
2,809,310	Stock	..	Do. Deferred	14	14½	13¾	14¼	..	.. ..	14⅜	14
250,000	£100	4%	African Direct, 4 per Cent. Debentures	97	100	97	100	4 0 0	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine	11½	12⅛	11⅛	12	5 8 4	Mar., June, Oct., Dec.	11⅜	11½
69,200	100	5%	Do. 5 per Cent. Bonds	102	104	102	104	4 16 2	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	..	..
..	$100	..	Commercial Cables	103	105	112	116	..	..	103¾	103
16,000	£10	9/0	Cuba Submarine	12¾	13¼	12¾	13¼	6 15 10	February and August	13⅛	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3½	4	3½	4	..	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October..	9¼	..
60,710	20	3/6	Direct United States	10¼	10½	10⅜	10⅝	6 11 10	Jan., Apr., July, Oct.	10 7/16	10 5/16
400,000	10	2/6	Eastern	14	14½	14	14¼	4 11 3	" "	14 5/16	14
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15 7/16	15 5/16
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108⅛	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	108	111	108	111	4 10 1	February & August	108⅛	..
250,000	10	6/6	Eastern Extension xd	14	14⅛	14	14¼	4 18 3	Jan., Apr., July, Oct.	14¼	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	101	103	101	103	5 16 6	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July ..	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	100	103	100	103	4 17 1	" "	101⅛	100⅛
180,227	10	2/0	Globe Telegraph and Trust	9⅛	9⅜	9⅛	9⅜	5 6 8	Jan., Apr., July, Oct.	9 5/16	9⅛
180,042	10	6%	Do. 6 per Cent. Preference	15⅛	15⅜	15⅛	15⅜	3 18 1	" "	15⅜	15⅛
150,000	10	5/0	Great Northern	15¾	16¼	15½	16	4 13 9	Jan., April, and July	15⅞	..
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100	103	100	103	4 17 1	January and July ..	102⅛	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	105	108	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	37	39	37	39	6 8 2	April and October ..	..	..
33,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7¾	8¼	7¾	8¼	6 1 3	April and October..	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	112	116	112	116	..	" "	114	..
15,609	£10	5%	West African xd	9	10	9	10	5 0 0	..	9⅜	9¼
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	100	103	4 17 1	March & September	101⅛	101
30,000	10	2/0	West Coast of America	5⅜	6¼	5	6	..	January and July ..	6⅛	
150,000	100	8%	Do. Debentures 8%	106	110	106	110	7 5 6	June and December	..	..
88,321	10	Nil.	West India and Panama	2⅜	2⅝	2½	2¾	..	..	..	..
34,563	10	6/0	Do. 1st Preference 6%	11	11½	11	11½	5 4 4	April and October..	11 5/16	..
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12½	13½	12½	13½	..	..	13	12¾
64,572	15	6/0	Western and Brazilian	10⅛	10⅝	10	10½	5 14 3	May and November	10 5/16	10⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	..	..	..	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3¾	4¼	3¾	4¼	..	..	..	..
200,000	100	6%	Do. 6 per Cent. Debentures, Series "A"	106	109	106	109	5 10 1	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debentures, Series "B"	104	107	104	107	5 12 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5⅓	Consolidated Telephone Const. and Maintenance	1/16	1/8	1/16	1/8	..	Yearly	0	..
220,000	£1	3%	Oriental (11s. paid)	¼	⅜	¼	⅜	4 8 3	Yearly	..	..
336,875	5	3/0	National xd	5	5¼	4⅞	5⅛	5 17 1	June and December	5¼	4 15/16
49,825	5	1/4½	Do. New	..	..	..	..	..	..	..	..
15,000	10	..	Do. 6 per Cent. Cumulative 1st Pref. xd	12¼	12⅝	12¼	12⅝	4 14 1	June and December	12⅜	..
15,000	10	..	Do. 6 per Cent. Cumulative 2nd Pref. xd	10¼	10⅝	10	10⅜	4 15 3	" "	..	..
209,750	1	..	South of England, Ordinary	¼	..	⅛	⅜	..	..	..	..
20,000	5	1/9	Do. 6 per Cent. Cumulative Pref. (£3 10 paid)	2⅛	3⅛	2¾	3¼	..	..	..	..
55,000	5	2/0	United River Plate	4¼	4⅝	4	4⅛	..	January and July ..	..	..
146,000	Stock	..	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..	..	..	..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
155,000	£5	..	London Electric Supply	1⅞	2⅛	1⅞	2	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4½	4⅞	4	4⅜	..	..	..	..
42,853	5	..	Westminster Electric Supply	1½	1¾	1¼	1⅝	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1⅞	2	1⅞	2	..	..	..	..
63,416	2	1/2	Do. Preference	1⅝	1⅞	1⅝	1⅞	..	..	..	..
20,000	5	..	Crompton and Co., 7 per Cent. Preference Shares.	5⅛	5⅜	5¼	5½	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..	..	..	..	..	..	..	..
409,000	10	..	Electric Construction	7⅞	8⅛	7⅞	8⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5⅛	6	5	5⅜	..	..	5⅜	5 1/16
20,000	5	..	Fowler-Waring Cables	2	2⅛	2	2⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works. xd	18½	19½	18½	19½	5 2 7	February & August	18 1/16	18⅛
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	103	105	102	104	4 6 7	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5	5⅛	5	5⅛	3 16 5	..	5 3/16	5 1/16
37,350	12	36/0	Telegraph Construction and Maintenance xd	43	45	42	44	5 9 3	March and July.....	43¼	42⅛
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100	102	100	102	4 18 0	..	..	..



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THE ELECTRICIAN:

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NOTES.

He who would venture to define the whole duty of a consulting engineer may reckon on the loss of some friends; and any learned Institute that might essay the task would infallibly make many enemies. The London Chamber of Commerce might discuss it, but their resolutions would bind no one. The Institution of Electrical Engineers would probably shirk it; although the Royal Institute of British Architects have not only successfully framed careful rules, but prescribe fees. We have no intention of grappling with the problem; but we are bound to notice special cases when complaints reach us, for such complaints need ventilation. One question was alluded to in the correspondence columns of our last issue, and an evil arising from this same question was discussed briefly by one of our contemporaries last week. It is, however, a matter concerning the true consulting engineer with which we have to deal at present, and not the contractor who dabbles in a practice which should be distinct from his own.

The Corporation of Brighton, for it is useless to disguise the names and particulars, allowed a somewhat discreditable muddle to take place some months ago; and, when that was all over, Mr. Shoolbred was instructed to prepare a specification and plans for the electric lighting. This, of course, they were justified and well advised in doing. But, before they had made sure of getting the money necessary for carrying out the work, they instructed their consulting engineer to invite tenders. This he did, on the authority of the Corporation. We have seen neither the Bradford specification nor that for Brighton, and are not prepared to criticise them from hearsay. A specification for the lighting of a town unfortunately follows no precedent or established form. It may give no more than a schedule of the lights, an indication of the site, or a choice of sites for the station, and a few general conditions. If the consulting engineer is asked to give no more than this, throwing the whole of the design upon the contractors, it does not follow that the results will be unsatisfactory, for he may carefully select the best scheme, and conscientiously see that it is carried out. Such a course entails an expense of, say, fifty pounds on each contractor, in calculations, visits, drawings, and estimates. The terms may be more precise, varying from a mere schedule, up to the specification which was drawn up for St. Pancras. Experience has shown that the full detail, including quantities, which the architect provides, is the most satisfactory to all parties; and Local Authorities should stipulate and pay for a complete specification, about which there can be no uncertainty.

We were surprised to find an unusually large difference between the highest and the lowest tenders in the list which we published on July 25th; and further to find that several firms sent in two tenders for dynamos, and Messrs. Siemens and Co. no less than four. We understand that the specification was very precise in some details, such as the manner of mixing the concrete; and, on the other hand, no proper drawings were provided, and not even a maximum speed for the engines or dynamos was specified. Even if the pressure or the system had not been defined, the matter might have been settled satisfactorily by a careful selection of the best. But we are informed that after the Corporation (having at the time no funds for carrying out the work) had received the tenders, they "allowed them to be messed about," how, or by whom, we know not; but with the result that certain contractors were asked to tender again, and others, some of them leading firms, were not invited. We have not inquired whether the specification for the second batch was identical with the first, or whether it had been amended, or whether the amendments, if any, had been suggested by some of the first tenders. At all events, the proceeding was one which is unworthy of a body in the position of the Corporation of Brighton, and which, as it has caused considerable irritation, we hope will not be repeated. We understand that the specifications for the St. Pancras lighting were very complete, and gave a full bill of quantities; but the result, as given in the list of tenders which will be found at the end of this issue, does not show any closer running as to prices. Messrs. Siemens and Co. is not the only firm who have in this case also had more than one bite at the cherry.

If rumour speaks truly, a very important advance has just been made in electro-metallurgy. Hitherto it has been found impossible to produce by electro-deposition a satisfactory plating of aluminium. The word "impossible" possesses, however, no finality to the electrician; and we hear with great satisfaction that one of the most enterprising of electrical firm has just made arrangements to secure and develop the newly-invented process for the deposition of aluminium, and of some new alloys which, apparently, have uses of very great importance.

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THE Southwark Subway, the progress of which has been watched with interest, is not easily recognisable under its new name of the City and South London Railway. The report, which we publish in another column, gives no ground for the supposition that there has been any hitch in the work. That electric railways and tramways have sometimes been opened before the work was half finished is no reason why any undue haste should be made in this case, in which stations have been built and fitted. Mr. GREATHEAD'S line is far more likely to be a success than if a few sneers at the apparently slow progress had induced him to hurry the construction and to make a premature start.

THE concluding Paper of the Institution of Electrical Engineers at Edinburgh by Mr. A. R. BENNETT described a number of experiments with radiometers. The majority of these were due to thermal effects and to air currents, and the direction of rotation seems to have been very uncertain and capricious. Two or three experiments employed electricity. In one of these the vanes were fitted with metal caps working on wire pivots fused in the glass. Such radiometers, Mr. BENNETT says, form condensers having the inner coating, the vane, free to move. The dielectric is the rarefied air, and the glass the outer coating. When the vane is connected to one pole of an influence machine, it rotates until the condenser is charged, and then stops; when the current is arrested, the vane rotates again in the same direction, until the greater part of the charge is lost. The action is increased by coating the outside of the glass with tinfoil. Mr. BENNETT'S experiments appear to be due to the combined effect of an ordinary brush discharge, and of the more refined actions which have been investigated by Mr. CROOKES in high vacua.

FEW if any of us pay rates and taxes with perfect spontaneity; and, therefore, the Institution of Civil Engineers is, we suppose, to be congratulated on having succeeded in resisting the demands of the Commissioners of Inland Revenue, who claimed 5 per cent. of a certain portion of their income. The decisions of the judges contain examinations into the meaning of the word "science," and more than one encomium on the value of the "body politic" to whose hospitality electrical engineers are so much indebted. "Any man who wants most effectively and successfully to practise the profession of a civil engineer will join the Institution," "I cannot conceive in what better way the promotion of mechanical science, and in particular of those branches of mechanical science which lie within the province of civil engineering, could be effected."

THE article by Mr. BATHURST in the *Electrical World*, of which we give an abstract in another column, though it is of a lower order of merit, may be taken as the complement to the Paper read by Mr. ADDENBROOKE last winter on "Electrical Engineering in America." The apology for ugly and cheap work is clearly made. The author does not appear to suggest that the "open cleat work" is more likely to give rise to accidents than the more neat-looking English style. It is rather amusing to learn that the author has been unable to obtain any actual figures of insulation resistances of the popular method of wiring.

ONE interesting point in this account is the comparison between "centre distribution" and the "free system." We do not remember having heard these terms before; but the latter evidently means the method of wiring with mains, sub-mains, branches, and smaller branches, which we hope is not so common as Mr. BATHURST seems to imagine. The "centre distribution" means the method of tapping from the mains as many branches as there are lights, or at all events one for each switch. It appears to us that the questions of the cost of labour and the cost of copper are quite insignificant here, as compared with the great advantage of grouping all the joints and therefore all the cut-outs in one accessible spot. An old excuse for bad joints used to be that they were placed in an awkward position, and there was no room to handle the soldering iron; and the excuse was as reasonable as the directions of the engineer who suggested the position of the joint were unreasonable. The cut-outs should be placed in an easily reached and convenient position, and such a position will allow the jointer to do good work. Soldered joints under the floor are an abomination; they are difficult to make, and impossible to inspect. In our opinion, the whole of the lights on each floor of an ordinary house should be run on separate circuits to the mains, and these should run nearly to the top of the house.

THE first, and probably the last, execution by electricity has taken place in America. We presume that all who were concerned in the matter are so ashamed of themselves that comments are superfluous. For sensational accounts of disgusting details we refer our readers to other journals.

THE sum of £47,500 payable as to £23,000 in cash and £24,500 in the fully paid-up shares of a company with a capital of £100,000, is an altogether absurd price to pay for machines to drill square holes. We saw a machine drilling square holes at the Exhibition at Paris in 1878, and believe that another was shown at the Inventions Exhibition. We did not pay attention to the present tools until they had been noticed at some length by our contemporaries. On the occasion of our visit the machines could not be said to be drilling;—they were merely scraping away the metal. No such thing as a clean cut-out boring was to be seen. The tool scrapes with one edge, and is subject to severe side strain. The statement in the prospectus that "a driller will be able to turn out work as accurately as an experienced fitter has hitherto been able to do" is greatly exaggerated, and we saw no grounds whatever to support the statement that "the relative cost of drilling round holes and making square holes was in the proportion of about 1 to 36," and that "a square hole can now be drilled by the company's drilling machines at about the same cost as a round hole." We do not know who wants to drill square holes; in the list of trades who are expected to do so, watch and clock makers and turnkey makers are given: surely it is not expected to make watch-keys thus?

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One of the only uses we can think of is the making of box-keys. Reports and opinions as to the validity of the patents are alluded to, but no engineer's or manufacturer's opinion as to the practical value of the invention is given.

We have been expecting it for a long time past, and it has come at last. The phonograph, after attempting to pose as a scientific instrument, then as an indispensable adjunct to every well-appointed office, and, failing that, as a means of entertainment at parties and *conversaziones*, has at length found a resting place in the squeaking doll. It was obvious so soon as she was taught to say "mamma" and "papa" that her education would have to be completed, and this by means of the phonograph. As a nursery plaything, or in any other equally humble capacity, Mr. Edison's much-belauded patent will do some service. For one thing it may be trusted not to talk as much nonsense of itself as is talked about it; and our children as they grow up will discover, what their parents appear to be unable to realise, that the phonograph is not an electrical appliance. If we are not mistaken, it was announced a long time ago that a very large consignment of improved phonographs had left New York in a specially chartered vessel. We fear she must have gone down with all hands.

Marthalen.—The village of Marthalen, in Zurich, has adopted the electric light in its streets.

Kidderminster.—The Corporation have resolved to apply for a Provisional Order for electric lighting.

Bellinzona, Switzerland.—The Town Council has decided to carry on electric lighting. The work is to be entrusted to Messrs. Alioth, of Basle. It is to be completed by November 15th, at a cost of £5,200.

Electric Lighting in Edinburgh.—It was agreed on July 31st to recommend the Edinburgh Town Council to take steps to obtain a Provisional Order giving them power to control the introduction of electric lighting into the city.

The Gas of Cork.—In the course of a judgment at the recent Cork Assizes, on a dispute about some gas burners Mr. Justice Gibson said, "Cork gas appears to be a peculiar article, odoriferous, and giving a sickly and insufficient light."

Verona.—The installation at Verona, which was entrusted to Messrs. Schuckert and Co., Nuremburg, is nearly completed, and it is expected that 30 arcs and 1,200 incandescents will be at work this month. Low-tension continuous currents are used.

National and Colonial Exhibition in Lyons.—A National and Colonial Exhibition will take place in Lyons during the year 1892. The sections for silk and electricity will be international, and a special section, without competition, will be reserved for the foreign exhibitors.

Bromley.—The local syndicate for electric lighting at Bromley have resolved that they will not favour any particular company in carrying out their scheme, but will employ their own engineer to get out estimates, and then invite tenders from some of the best firms.

Southampton.—At a meeting of the Town Council on Wednesday it was decided, by 18 votes to 6, to decline to purchase the licence of the local electric lighting company for £750. It was argued that the Corporation should do the lighting, and that in no other instance had any such rights been purchased.

Cassel.—The local authorities have decided on the erection of a central station, and have accordingly purchased some mills on the river 2½ miles above the town for £13,250. At present 3,000 incandescent lamps are to be installed, but this number is to be largely increased; 2,800 private incandescent lights have also been applied for, besides a number of arcs.

St. Helen's.—The Corporation have received notice from the Electric Installation and Maintenance Company (Limited) and the Lancashire and Cheshire House-to-House Electricity Company (Limited) of their intention respectively to make application to the Board of Trade for a provisional order. The Gas Committee recommend the Corporation to oppose the applications.

Telephone between Paris and Bordeaux.—The City of Bordeaux some time ago asked for a telephonic line to Paris. M. de Selves, of the Administration of Telegraphs, has informed the Mayor that the erection of the line will be commenced as soon as the Municipal Council of Bordeaux votes £18,000 (450,000fr.) as representing their share of the expenses demanded by the State.

Underground Mains in Paris.—Contractors have been obliged to place their mains under the pavements at a distance of at least one metre from the façades of the houses, thus keeping a space for municipal mains. M. Cochin remarked at a recent meeting of the Municipal Council that in certain streets the pavements are less than one metre wide. It was decided that where necessary the limit should be reduced to 60 centimetres.

The Copper Ring.—The Court of Appeal in France has decided that the coalition between M. Secrétan and the Copper Mining Companies was not illegal, since each company was perfectly aware that there were contracts with other mines. Moreover, in no contract had M. Secrétan engaged those who combined, not to sell or to sell only at a fixed price. The sentence of six months' imprisonment is not, however, modified, although the fine of 10,000fr. is reduced to 3,000fr.

Electric Light at the Vienna Stadthaus.—This installation is to be increased to 3,536 glow lamps, the present number being 2,756, so that it already ranks as a large private installation. From the *Zeitschrift für Electrotechnik* we learn that the laying of the conductors of the International Elektricitäts Gesellschaft in Vienna is being rapidly proceeded with. The primary conductors are now laid throughout the whole circuit, and the secondary conductors are now being put down.

Telephone in the West Riding of Yorkshire.—It is intended to charge five guineas per annum for every instrument, and in cases where more instruments than one are employed on the same premises, one guinea each, and it is proposed to establish inter-town communication with an exchange. To begin with, the promoters wish to extend operations to five large towns in the West Riding, namely, Leeds, Bradford, Halifax, Dewsbury district, and Huddersfield. It is proposed to have a double circuit of wires.

Breslau.—The Town Council has decided to grant 1 million marks (£50,000) for the erection of a central station. The project of Messrs. Siemens and Halske will probably be accepted. The central station will at first have a capacity of 8,000 lamps, to be afterwards increased to 30,000. Continuous currents will be used, and the lamps within a radius of 1,200 metres will be fed directly from the machines. Outside the limit, the system will be supplied by accumulators charged during the day.

Cologne.—The municipal installation is being pushed on with. Owing to the ground under the streets being already crowded with gas and water mains, the lighting cables will be laid principally under the pavements. At first, the main thoroughfares only of the old part of the town are to be lighted, for which 12,000 lamps are required. For the supply of these, two steam engines of 250 horse-power and two of 500 are to be put down. The price to be paid is 6·06 pf. ($\frac{3}{5}$d.) per 16 candle-power lamp hour, which appears rather high.

New Insulating Materials.—A series of new insulating materials have been discovered by Mr. G. E. Heyl, of Charlottenburg. To one of them he has given the name, Heylit; it is made in three grades, melting at 60deg., 100deg., 120deg., and 180° C. respectively. A sheet of the last grade, 10cm. square, and 1mm. thick, has a resistance of $19{,}300 \times 10^6$ ohms, as shown by tests made at Munich laboratory. It is claimed that the new insulating material gives a lower capacity and higher insulation than any of the ordinary insulators. It is also much cheaper, and is unaffected by acids or chlorine.

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Dusseldorf.—The *Koelnische Zeitung* reports that on the 29th July the Corporation of Düsseldorf-on-the-Rhine have resolved to erect a central electric lighting station for about 20,000 incandescent lamps at the amount of two millions of marks, with direct current and accumulators. The main station is to be built near the new gasworks, two smaller stations in the Bleichstrasse and the Grünstrasse. After a Paper read by the consulting electrician, Prof. Kittler, of Darmstadt, the execution of the total plant was laid in the hands of Messrs. Schuckert and Co., Nuremberg.

Electric Lighting at Exeter.—The Special Committee appointed to consider whether the Council should themselves apply for a Provisional Order for the supply of electricity for public and private purposes within the city of Exeter, recommended that the Exeter Electric Light Supply Company be requested to supply a draft of their proposed Provisional Order within six weeks, and that a special meeting of the Committee be called to consider the same, and that in the event of no draft being submitted by that date, a meeting of the Committee be convened to consider the course the Council should adopt. After a little discussion the report was adopted.

Search Lights for Military Purposes.—Not long ago, says the *Army and Navy Gazette*, interesting manœuvres were gone through at Tempelhof with the object of testing the value of the electric light for discovering the advance of an enemy seeking to surprise a position by night. The necessary arrangements were made by the pioneers of the Garde, who erected dynamos and established lamps with powerful reflectors. In the evening the 2nd Battalion of the 3rd Regiment of the Garde arrived on the spot to dig trenches, and some companies of pioneers, screened by the railway embankment, were to attack them in their work. Briefly, the attack failed, for every movement of the advancing party was clearly distinguishable from a great distance.

The French Submarine Cables.—In reply to Mr. Henniker Heaton, Mr. Raikes said last week that a substantial profit will no doubt result from the purchase of the submarine cables between this country and the Continent, but it would be premature at present to estimate the amount of that profit in view of the condition of the cables. Some of these cables are very old, and it is possible that before long a considerable expenditure may have to be incurred in renewals. The number of words in Anglo-French telegrams has risen from 13,376,333 in the year to March 31, 1889, to 15,495,791 in the year to March 31st last. Other telegrams have passed over the Anglo-French cables, but he was not able to give separate particulars with regard to them.

St. Moritzbad.—According to the *Elektrotechnische Zeitschrift* the alternating-current scheme for this central station is to be abandoned. The turbines, &c., are to be to the plans of Messrs. Largin and Grossman, Lucerne. Three Girard horizontal turbines, supplied by Rieter and Co., developing 160 horse-power at 250 revolutions, will be put down. The power will be sufficient to run 4,000 lamps, but it is considered advisable to be able to augment this, so that probably accumulators will be used. Four continuous-current machines will be driven in series, and will supply a current at 8,000 volts to the transforming station, which is six miles distant. Here eight transformers will reduce the tension to 100 volts, the three-wire system being used. It is stated that this change is due to the advice of Herr Uppenborn.

The Victoria Torpedo.—Messrs. Heenan and Froude are manufacturing a torpedo, invented by Mr. Murphy, of Melbourne. It will, according to *The Times*, have a range of 2½ miles; it is 24ft. in length, and is driven by a screw-propeller, worked by compressed air. The steering and control are effected by electricity, by means of three lines of seven strands each, forming a cable which weighs 1½oz. to the yard. The torpedo carries 1,200 yards of cable coiled up in a free coil in a chamber full of oil. When the torpedo is started, cable is payed out from shore; but after a certain speed is attained, for every yard payed out from shore nine yards are uncoiled from the torpedo. Three motors, weighing 2lb. 7oz. each, are carried; and these control the rudders, starting gear and the exploding arrangement, each electrical impulse giving a definite effect.

Injuries and Death from Lightning.—On Saturday afternoon during a cricket match at Aldershot a brilliant flash of lightning, followed by a loud peal of thunder, appeared to strike a tree under which some soldiers were seeking shelter. Surgeon Frank, of the Medical Staff, rushed to the spot with the rest of the players, and after untiring efforts at resuscitation successfully restored five of the six men who had been struck. One, however, was found to be lifeless. The tree around which the group of men were sitting showed no mark except at the base, where the bark for about two feet was stripped away. It was stated at the inquest that had it not been for Surgeon Frank, the other men would have died; but, as the result of his persistent efforts to restore animation by means of artificial respiration, especially in the case of Private Evans, who was supposed to be dead, they were all saved.

Electric Tramway on Southend Pier.—The electric tramcar on the Pier at Southend has been completed by Messrs. Crompton and Co. The engine, boiler, and dynamo are situated under the arches close to the entrance of the Pier, and the current is conducted along the central rail for three-quarters of a mile down the Pier. The car holds about 40 persons, and travels at the rate of about 16 miles an hour, making a journey in about 3½ minutes which takes nearly 15 minutes by the ordinary horse traction. The line was certified by Dr. Hopkinson on Friday last. On Saturday afternoon, after a few trial runs, it was handed over to the Local Board for public use at four o'clock. A large number of people availed themselves of it; and on Monday, Bank Holiday, the car was well patronised. This is a very satisfactory exhibition of electric traction; and as it is situated only a short distance from London, it will, no doubt, be visited by many interested in this particular work.

The Institute of Medical Electricity.—This Institute has recently removed to larger and more commodious premises at 35, Fitzroy-square, W. Increasing work, and the need for being nearer the great medical centres of Harley-street and Wimpole-street, induced the Directors to make the change. They have taken one of the old-fashioned substantial residences on the Grafton-street side of the square, and it contains many large, light and airy rooms well adapted to the purposes of the Institute. The drainage has been entirely renewed, and the house redecorated from attic to basement. The apparatus has been carefully removed from the old quarters at 24A, Regent-street, and new has been added to it, so that greater facilities are now available for electrical treatment, which is carried out only under medical sanction. Increasing use is being made of treatment by "cataphoric medication," or the passage of drug solutions through the skin by means of electric currents. This method of obtaining strongly localised action has been developed from its experimental stage, and first brought into practical use at this Institute under the auspices of Dr. Arthur Harries and Mr. H. Newman Lawrence.

Manufacture of Vermillion by Electrolysis.—In a wooden vat, one metre in diameter and two metres deep, circular plates 15 centimetres wide are placed against the sides, and on these the mercury is exposed, one centimetre deep. These plates are connected with the positive pole of a dynamo. At the bottom of the vat is a sheet of copper electroplated with iron, and connected with the negative pole. The vat is filled with a solution of 8 per cent. of nitrate of ammonia, and 8 per cent. of nitrate of soda. A worm, pierced with holes, supplies a constant and regulated current of sulphuric acid; the excess of gas escapes by a tube projecting from the lid. A screw agitator keeps up a thorough mixture in all parts of the liquid. When the current passes it immediately forms a precipitate of red sulphide of mercury. Attempts have been made to dispense with the current of sulphuric acid by making up the bath with:—Water, 100 litres; nitrate of ammonia, 8 kilos; nitrate of soda, 8 kilos; sulphide of soda, 8 kilos; sulphur, 8 kilos. Under these conditions one need only add sulphur and mercury to extract at the end of the operation vermillion which rivals that which can be obtained by sulphate of ammonia.

Heilbronn.—We learn from the *Elektrotechnischer Anzeiger* that the terms of the contract for the supply of light and power in this town were definitely settled upon at the last

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meeting of the Town Council. By this agreement the cement factory at Lauffen-on-the-Neckar, which has about 1,200 superfluous horse-power at its disposal, obtains the sole right to supply the town with electricity for a long term of years. The tariff is fixed on the basis of a charge of 3pf. (0·36d.) per lamp hour for 10 candle power lights, with a yearly demand of 300 hours, and 2·4pf. (0·29d.) per hour if the yearly demand reaches 1,000 hours. For power, 27pf. (3¼d.) per horse-power hour are to be charged for a yearly consumption of 1,000 horse-power hours, with a reduction to 15pf. (1¾d.) per hour if 3,600 horse-power hours are taken in the year. These prices are considerably below the cost of power obtained from any other source. As already more than half the available power has been subscribed for, accumulators will probably have to be used. The installation is to be proceeded with at once, so that it may be got to work before the close of the present year. The capital of the Company is to be increased by 300,000 marks (£15,000).

The Utilisation of Waste Coal.—The Commission recently appointed by the Legislature of Pennsylvania to consider the question of coal waste, and to devise, if possible, some means of utilising the culm, has commenced its sittings. The Commission consists of Colonel J. A. Price, President of the Scranton Board of Trade; Mr. P. W. Sheafer, a distinguished mining engineer, of Pottsville, and Mr. Eckley B. Coxe, a well-known coal operator. Mr. Sheafer has estimated that there are 100,000,000 tons of waste coal in the anthracite regions. A portion has been destroyed by fires, which often burn for years in a culm bank; and much of it is mixed with slate, ashes and stones, so that it is worthless. The most valuable banks of waste are those where the small coal has been kept separate from slate and ashes. The utilisation of this immense quantity of waste is a very important matter, and the Commission will aim to find out if that which is now a source of expense cannot be made a source of revenue. It is interesting to note in this connection that at Scranton the culm coal from the pile adjacent to the generating station of the electric tramway is used, the price paid per ton being 5d., which results in the cost of coal per car mile coming out at ·014d. per car mile, as against ·25d. at Cleveland and ·36d. at Washington.

Extension of Electric Lighting at the Central Station, Glasgow.—Contracts have been closed for an extension of electric lighting at the Central Station of the Caledonian Railway, the contractors being Messrs. Mavor and Coulson, George-square, Glasgow; and within the extension there will be included the whole of the hotel premises, all the station offices, the booking offices, platform bookstalls, stores, &c. The present engine-room, which is on the basement floor, underneath the passenger station, is to be entirely remodelled; and the engine, which at present generates the current for the arc lamps over the passenger platforms and elsewhere, and for the incandescent lamps in a portion of the hotel, will be removed, and two new engines will in due course be installed for the permanent lighting. There will be two powerful dynamos, each being capable of supplying current to about 650 16 candle-power lamps, and one having about half that capacity. The speed of these machines will be 600 revolutions per minute. In all there will be from 1,600 to 1,700 lamps in the installation when it is completed. Provision has to be made in the wiring for circuits to replace those already in use. The wiring in the hotel is to be done in sections, two on each floor, and it is to be done under teak or other hard wood, so as to match, as far as possible, the woodwork of the various rooms. Some of the light being required during the day, one of the engines will always be running. The work has already been commenced by Messrs. Mavor and Coulson, and the intention is have to it finished in the course of three months—that is to say, by the end of the month of October.

Diamagnetism Tested by Carnot's Principle.—In a recent number of the *Philosophical Magazine* appeared a short Paper by Mr. J. Parker, of Cambridge, in which Carnot's principle was applied to diamagnetism. An oversight occurs in the Paper, which has since been corrected by M. Duhem, who has adopted and extended the substance of the Paper. The present state of experiment and theory on diamagnetism may be briefly stated thus:—(1) If a piece of bismuth be placed near a strong iron magnet in the open air, the bismuth behaves as if repelled by the iron. (2) If the same experiment were performed in a vacuum, it is shown by Carnot's principle that the bismuth would not be repelled, and might be attracted. It is therefore concluded that if the experiment were performed in a place from which the air could be pumped away at will, the repulsive force on the bismuth would become zero when the pressure of the air was sufficiently reduced, and by continuing the exhaustion still further it would probably become attractive. The action of the bismuth in the open air will be explained if one remembers that both the iron and the bismuth are surrounded by a mass of magnetised air, so that the behaviour of the bismuth is due to three causes—(1) The attraction of the iron magnet. (2) The attractions of the magnetised atoms of air. (3) The resultant of the unequal pressure of the air over the surface of the bismuth. The conclusions of this Paper naturally lead us to question the propriety of making our "absolute" units of electricity and magnetism depend on the actions between bodies surrounded by electrified or magnetised air, about which all that is known is that, at some distance away, the air with which it is in equilibrium has a measurable pressure.

The Electric Lighting Acts.—The report by the Board of Trade respecting the applications to and proceedings of the Board under the Electric Lighting Acts for the past year has just been issued. It is a very elaborate document, and contains a complete list of all the Orders and applications for Orders, with statements of reasons for refusal in cases where the application was not granted. We take the following epitome from *The Times*:—There were 161 applications, of which 45 were made by local authorities and 116 by companies or individuals; 23 related wholly or in part to the county of London. A large number of the applications related to districts outside the metropolitan area; and it was found that considerable alterations would be necessary before the model form of Order settled last year for the metropolis could be made applicable. The Board of Trade therefore settled a model form of Provisional Orders based upon those confirmed by Parliament last Session which would be applicable to—(1) Orders granted to Local Authorities, and (2) Orders granted to companies outside the Metropolis; and which, in the case of the Metropolis, followed as closely as possible the forms adopted last year. The Orders granted to companies have, in every case, been granted with the consent of the Local Authority of the district; but, in one instance, the Board of Trade considered it necessary to hold a local inquiry. In several instances, applications were received from the Local Authority and also from one or more companies from the same area. In such cases the Board of Trade have, in accordance with their rules, given the preference to the application of the Local Authorities. In the Orders and licenses granted to Local Authorities the Board of Trade have, after careful consideration of the representations made to them in favour of such a course by the Local Authorities acting as representatives of the ratepayers, inserted a clause authorising the Local Authority to transfer their powers, duties, and liabilities to any company or person with the consent of the Board of Trade. The regulations prepared by the Board of Trade for the purposes of Section 4 of the Electric Lighting Act, 1888, referred to in the last report, have been settled, and in any case in which their attention has been called to the existence of overhead electric lines to which that section would apply, a notice has been served by the Board of Trade upon the owners or users of such lines requiring them to comply with the regulations. These regulations are given in an appendix to the report. A question having arisen as to the interpretation to be placed upon the portion of the schedule of the Electric Lighting Act, 1882, defining Local Authorities in Scotland, the Board of Trade consulted the Scotch Office, who were of opinion that in certain cases in which authorities in Scotland were authorised to supply gas, they were not the Local Authority for electric lighting purposes in the capacity in which they supplied gas, and would not be able to utilise the gas rates for electric lighting purposes in the event of their obtaining powers to supply electrical energy. A Bill to amend the schedule was therefore introduced.

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MAGNETISM IN IRON AND OTHER METALS.*—XXVI.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 340.*)

§ 98. **Further Experiments with Wrought Iron.**—In the following experiments bobbins were used of a shape suited to give a fair approximation to a uniform field, and hence the outside field close to the neck is taken as the measure of H :—

TABLE XI.—*Lowmoor Wrought Iron.*

H	B	I	μ
3,080	24,130	1,680	7·83
6,450	28,300	1,740	4·39
10,450	32,250	1,730	3·09
13,600	35,200	1,720	2·59
16,390	36,810	1,630	2·25
18,760	39,900	1,680	2·13
18,980	40,730	1,730	2·15

TABLE XII.—*Swedish Iron,* "L[S]Lancash." *Brand.*

H	B	I	μ
1,490	22,650	1,680	15·20
3,600	24,650	1,680	6·85
6,070	27,130	1,680	4·47
8,600	30,270	1,720	3·52
18,310	38,960	1,640	2·13
19,450	40,820	1,700	2·10
19,880	41,140	1,700	2·07

TABLE XIII.—*Fine Swedish Iron,* (L) *Brand.*

H	B	I	μ
5,310	25,670	1,620	4·83
17,680	38,080	1,620	2·15
19,240	39,540	1,620	2·06

In this last iron, which is described as the finest and most expensive iron used in commerce, made by the Walloon process, the saturation value of I seems to be specifically rather less than in other brands. The saturation value usually found in wrought iron may be stated to be, in round numbers, 1,700. The state of saturation is practically reached, in soft metal, with a force of, say, 2,000 C.-G.-S. units; from this force upwards no material change can be observed in I, though the force be increased ten-fold.

§ 99. **Cast Iron and Steel in very Strong Fields.**—In cast iron the highest value to which B was pushed in these experiments was 31,760, with the result of reducing the permeability to 1·9. The saturation value of I in the sample tested was 1,240, and saturation was practically complete under a force of 4,000.

In hard steel the state of complete saturation is not so easily reached. The following test, which was made with a sample of Vickers' tool steel possessing much coercive force, exemplifies this. The test piece formed the central part of a bobbin with wrought-iron cones, built up in the manner shown in Fig. 71. By removing one of the cones, a loose coil on the neck could be slipped off to determine the residual magnetism, which in this case formed a considerable part of the whole. (The residual induction in the neck was about 8,000.) It may be doubted whether saturation was complete even in the strongest field.

TABLE XIV.—*Vickers' Tool Steel.*

H	B	I	μ
6,210	25,480	1530	4·10
9,970	29,650	1570	2·97
12,120	31,620	1550	2·60
14,660	34,550	1580	2·36
15,530	35,820	1610	2·31

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There appear, however, to be specific differences in the saturation values of I in different steels. In the following Table a summary of the results of experiments on other steels is given, showing in each case the highest force applied and the highest induction reached, along with (approximate) corresponding values of I and μ.

TABLE XV.—*Steel of Various Qualities.*

Description of steel.	Outside field (= H nearly).	B	B − outside field / 4π (= I nearly).	B / Outside field (= μ nearly).
1. Bessemer steel, containing about 0·4 per cent. of carbon.....	17,610	39,880	1770	2·27
2. Siemens-Martin steel, containing about 0·5 per cent. of carbon	18,000	38,860	1660	2·16
3. Crucible steel for making chisels, containing about 0·6 per cent. of carbon...	19,470	38,010	1480	1·95
4. Finer quality of crucible steel for chisels, containing about 0·8 per cent. of carbon.....	18,330	38,190	1580	2·08
5. Crucible steel, containing 1 cer cent. of carbon ...	19,620	37,690	1440	1·92
6. Whitworth fluid-compressed steel	18,700	38,710	1590	2·07

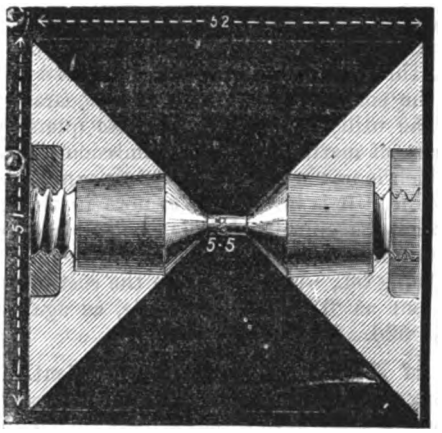

FIG. 71.

§ 100. **Hadfield's Manganese Steel in Strong Fields.**—Reference has been made in § 70 to the remarkable absence of magnetic susceptibility shown by this steel, which contains about 12 per cent. of manganese and 1 per cent. or less of carbon. In fields of ordinary strength this alloy has a sensibly constant permeability of about 1·3, as Hopkinson's experiments have shown.* Application of very strong fields, by means of the isthmus method, shows that the permeability, even under very great forces, remains constant as nearly as may be judged. One might expect that a material which resists magnetisation so strongly would show much coercive force; the reverse, however, is the case. Even the strongest force is unable to produce more than a trace of residual magnetism. The following is one of several experiments which agree in showing that the permeability of manganese steel, under any force up to 10,000 C.-G.-S. units, is practically constant with a value of about 1·4.

TABLE XVI.—*Hadfield's Manganese Steel.*

H	B	I	μ
1,930	2,620	55	1·36
2,380	3,430	84	1·44
3,350	4,400	84	1·31
5,920	7,310	111	1·24
6,620	8,970	187	1·35
7,890	10,290	191	1·30
8,390	11,690	263	1·39
9,810	14,790	396	1·51

* *Phil. Trans.*, 1885, p. 462.

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This permeability is so low that when the field is weak, the metal takes up scarcely any magnetism; on the other hand, since the permeability retains the same value in very strong fields, a respectably high intensity of magnetisation may be produced by applying a sufficiently strong force. The variations of μ in Table XVI. are irregular, and are no greater than may be ascribed to errors of observation.

§ 101. **Nickel and Cobalt in Strong Fields.**—With nickel and cobalt a state of complete saturation is reached without difficulty, as the following observations show. In the two specimens of nickel tested (Tables XVII. and XVIII.) the saturation values of I were about 400 and 515 respectively; the difference is perhaps due to differences in the amount of iron present: neither specimen was pure. The saturation value of I in cobalt appears to be 1,300, which is a little greater than the value in cast iron.

TABLE XVII.—*Hard-drawn Nickel (with 0·56 per cent. of Iron).*

H	B	I	μ
2,220	7,100	390	3·20
4,440	9,210	380	2·09
7,940	12,970	400	1·63
14,660	19,640	400	1·34
16,000	21,070	400	1·32

TABLE XVIII.—*Annealed Nickel (with 0·75 per cent. of Iron).*

H	B	I	μ
3,450	9,850	510	2·86
6,420	12,860	510	2·00
8,630	15,260	530	1·77
11,220	17,200	480	1·53
12,780	19,310	520	1·51
13,020	19,800	540	1·52

TABLE XIX.—*Cobalt (with 1·66 per cent. of Iron).*

H	B	I	μ
1,350	16,000	1,260	12·73
4,040	18,870	1,280	4·98
8,930	23,890	1,290	2·82
14,990	30,210	1,310	2·10

§ 102. **Summary of Conclusions from Isthmus Experiments.**—To sum up the results which have been arrived at by means of the isthmus method, the concluding paragraph of the Paper from which these figures are taken may be quoted.*

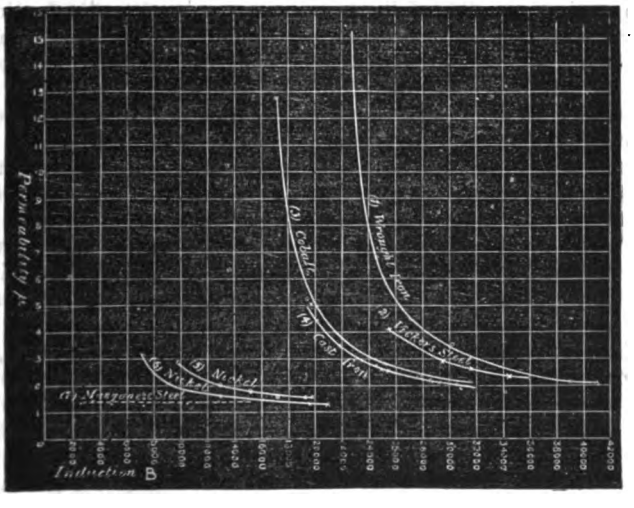

FIG. 72.—Permeability of Magnetic Metals when very strongly magnetised.

Under sufficiently strong magnetising forces the intensity of magnetisation, I, reaches a constant or very nearly constant value in wrought iron, cast iron, most steels, nickel, and cobalt. The magnetic force at which I may be said to become practically constant is less than 2,000 C.-G.-S. units for wrought iron and nickel, and less than 4,000 for cast iron and cobalt. In stronger fields the relation of magnetic induction to magnetic force may be expressed by the formula

$$B = H + \text{constant}.$$

For the particular specimens tested, the value of this constant (4π I) is about 21,360 in wrought iron, 15,580 in cast iron, 5,030 and 6,470 in nickel, and 16,300 in cobalt.

The experiments give a definite meaning to the term "saturation," as applied to magnetic state. When magnetism is measured by the induction B, the term saturation is inapplicable; there is apparently no limit to the value to which the induction may be raised. But, when we measure magnetisation by the intensity of magnetism I, we are confronted with a definite limit—a true saturation value, which is reached or closely approached by the application of a comparatively moderate magnetic force. There is nothing to show that the approach to this limit is not asymptotic; but in wrought iron it is practically reached before the magnetic force rises to 2,000 C.-G.-S., and after that a ten-fold increase in the force produces no material change in the intensity of magnetism.

The results are further summarised in Fig. 72, which gives curves showing the relation of the permeability μ to the induction B drawn from the data supplied by experiments on—

(1.) Swedish wrought-iron (Table XII.).
(2.) Vickers' tool steel (Table XIV.),
(3.) Cobalt (Table XIX.).
(4.) Cast iron (Table X., and other data).
(5 and 6.) Nickel (Tables XVIII. and XVII.).
(7.) Hadfield's manganese steel (Table XVI.).

(To be continued.)

INFLUENCE OF CURRENT ON THE FRICTION OF SLIDING SURFACES.

Several experiments have been made with the view of determining the effect of current on the friction of sliding surfaces. The results in one case were nil, though the experiments appear to have been carefully carried out; but the current density was small. More than one set of tests has been made with electric tramways, and it has been found that with a heavy current there was a distinct increase of adhesion, and, further, that when this was produced, a distinct pitting of the rails was noticed. It was suggested that a welding action had taken place, and this seems to be confirmed by the experiments of L. M. Schmidt, in the New York *Electrical Engineer*. The apparatus was a modification of a welding machine, the object of the tests being to ascertain whether during the passage of the working current the ordinary sliding contacts of the machine offered any appreciable increase of friction. Three sets of measurements were made—the first, to determine the static friction; the second, the moving friction; and the third, the effect of a lubricant. The static friction cannot be compared with the moving friction, for it appears to us that the effects were simply due to welding. Mr. Schmidt found an increase of the coefficient of friction of repose; a slight decrease of friction of the surfaces while in motion; and a very uncertain and variable effect when a mineral lubricant was used, generally increasing the coefficient of friction. The current density of 150 amperes per square inch of the surface is quite sufficient to account for welding as the cause of the results which were noticed. It is probable that with a good mechanical fit, a higher current density would be required before an appreciable increase of friction would be produced, since the resistance would be less, owing to the increased area of actual contact; while, on the other hand, comparatively rough or uneven surfaces touching in two or three places would naturally tend to weld when a sufficient current passed. The strength of the current required to produce a given

* *Phil. Trans.*, 1889 A, p. 242.

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apparent increase of the coefficient of friction would, therefore, depend very largely on the excellence of the mechanical fit. It is, of course, impossible that welding should take place while the sliding surfaces are in motion; but a small portion of the metal may be brought to a plastic state. This would tend to improve the accuracy of the contact by facilitating the wearing or the burning off of projections. A rapid sliding of the surfaces would in almost all cases, including that of the commutator and brushes of a motor, continually bring a fresh, and therefore a cooler mass of metal—say the commutator—in contact with the plastic part—say the brush. But the density of current with any decently-made brush should be far too small to give rise to any serious heating, and the natural wear affords the best facilities for a good fit.

The irregularity of the effect of the lubricant is not surprising when it is remembered that little or nothing was known about the ordinary action of lubricants until Mr. Tower made his well-known experiments on this important subject. It does not seem probable that the current which is employed for tramway work would often be heavy enough to produce any useful increase of adhesion, since, although the area of contact of the wheels with the rails is small, a new surface is being continually presented, offering a very different set of conditions to that of the sliding experiments of Mr. Schmidt.

THE EFFECT OF CIRCULAR MAGNETISATION ON THE RESISTANCE OF IRON.

BY HERBERT TOMLINSON, F.R.S.

It is now well known that the resistance of iron, nickel, cobalt, bismuth, and other metals, is increased by *longitudinal* magnetisation. Neither can there be any doubt that when a wire or rod of any of these metals carries a current, a magnetic field is created *circularly* around the wire, partly outside it, also partly inside it. The question has, therefore, naturally arisen, is the resistance which a wire of iron, nickel, cobalt, or bismuth offers to large currents different from the resistance which it offers to small currents? Before we attempt to answer this question let us examine the extent to which the resistance is affected by longitudinal magnetisation. In the accompanying table will be found some of the results obtained by the writer about ten years ago, a more detailed account of which can be obtained from the *Philosophical Transactions* for 1883, and the *Philosophical Magazine* for April, 1888.

Metal.	Condition.	Increase of resistance.* ΔR.	Magnetic susceptibility in C.-G.-S. units. κ.†	$\Delta R/\kappa$.
Iron	Annealed ...	23	30	0·8
Steel	Annealed ...	15	—	—
Steel	Very hard ...	0·7	—	—
Nickel ...	Annealed ...	81	9	9·0
Nickel ...	Unannealed	43	—	—
Cobalt ...	Unannealed	6	4	1·5
Bismuth...	Unannealed	0·2	−·000014	1500
Copper ...	Annealed ...	0‡	—	—

* In millionths, produced by 1 C.-G.-S. unit of magnetising force.

† The values of κ were determined for the same magnetising forces as those used for producing alteration of resistance. Within the limits of the experiments ΔR is roughly proportional to the force and also to κ.

‡ No change amounting to one in four millions could be detected with a magnetising force of 90 C.-G.-S. units.

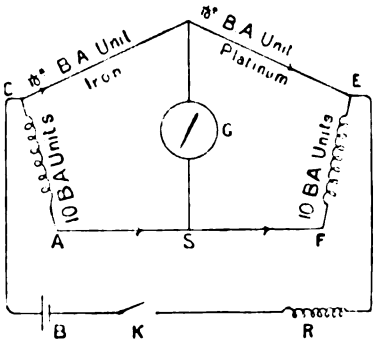
The numbers in the last three columns of the table refer to temporary magnetisation, *i.e.*, to the magnetisation which disappears on the removal of the magnetising force.

It will be noticed, in the first place, that the increase of resistance produced by unit force is in all cases *very minute*, so minute indeed that even with a force of 100 C.-G.-S. units the alteration of resistance of well-annealed nickel (the metal most affected by a force of given magnitude) would not amount to 1 per cent.

In the second place, it by no means follows that the metals which possess the greatest magnetic susceptibility are necessarily those which will be most affected in their resistance by a given force; the increase of resistance of nickel, for instance, being twice that of iron, whilst the susceptibility of the latter metal is more than three times that of the former.

It is, however, when we come to consider the last column that we meet with the most startling differences in the effects of magnetisation. The numbers in this column represent the increase of resistance which would be produced in each of the metals by magnetising them to such an extent that each cubic centimetre would possess unit magnetic moment. The effect of the magnetisation in this case would be twice as great for cobalt as for iron, twelve times as great for nickel, and about *two thousand* times as great for bismuth.

Though *longitudinal* magnetisation increases the resistance of iron to a comparatively small extent, yet, nevertheless, this increase is easily measurable with a good galvanometer; and did the circular magnetisation arising from the passage of a current through an iron wire produce results at all comparable with those produced by longitudinal magnetisation, we might reasonably expect to be able to detect them. Sir William Thomson has, however, shown that *transverse* magnetisation *decreases* the resistance of both iron and *nickel*; and though his experiments have been criticised by Beetz, who failed to obtain anything but negative results with transverse magnetisation, and attributed the decrease of resistance observed by Thomson to mere mechanical pull, the objection cannot well be sustained; for the writer has shown that not only would the alteration of resistance arising from the mechanical pull be too small, but also that this pull would produce *increase*, and not *decrease*, of resistance



in the case of *nickel*. Since, therefore, longitudinal magnetisation increased, and transverse magnetisation decreased, the resistance of iron, it still remained an open question as to what effect, if any, would be produced by circular magnetisation. The following arrangements (*see* illustration) were made by the writer for settling this point:—C D and D E are wires of well-annealed iron and platinum respectively, each of $\frac{1}{10}$th B-A. unit resistance. The diameter of the iron wire was exactly 1mm., and that of the platinum wire about 1mm.; the latter had, however, been drawn to such a gauge that the rise of temperature resulting from the passage of a current through it, caused very nearly the same increase of resistance in a given time as that caused by the same current in the iron; and thus, as a consequence, the current could be maintained for some minutes in both wires without very sensibly altering their resistance ratio. C A and E F are platinum-silver resistance coils, each of 10 B.-A. units. A F is a platinum-silver wire traversed by a sliding piece, S, which latter could, by a suitable spring and catch arrangement, be clamped to any part of the former; A F was extended over a scale divided into millimetres and having its zero in the centre. B is a Groves cell, K a key, R an adjustable resistance, and G a very sensitive reflecting galvanometer. It will be seen that the whole forms a Wheatstone's bridge arrangement, such that the main part of the current from B goes through the iron and platinum wires. The circuit of the galvanometer was always kept closed,* and the key K was only pressed down at each trial for a sufficient length of

* This should always be done when the alteration of resistance to be measured is very small, otherwise thermo-electrical currents may introduce serious error.

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time (about 10 seconds) to enable the effects of self-induction to subside, and the observer to ascertain the correctness of the balance. The first attempt was made with resistances 3 B.-A. units and 0 in R alternately; and in order to avoid bias in the observations the sliding piece was after each change of resistance shifted from its position, and covered with a silk cloth, so that it could not be seen whilst it was being adjusted anew. The following readings were taken in this way:—

Resistance in R in B.-A. units.	Position of S when a balance was obtained.
3	57·0
0	58·0
3	56·0
0	55·5
3	55·0
0	54·0
Mean position of S for R=3	56·0
Ditto for R=0	55·8

Shifting the sliding piece through one division of the scale corresponded to an alteration of resistance of 3 in 100,000, the sliding piece was throughout to the *right* of the centre of the scale, so that for R = 0 the resistance of the iron *appeared* to be *less* than for R = 3 by 3 in 500,000.

A similar set of trials was made with R alternately 0 and 10 B.-A. units with very similar results. As the resistance of the battery and connecting wires had been determined it was possible to find the values of the currents through the iron and platinum. If we denote the resistance of the iron with the lowest current by unity, we have the following values for the resistance with the other currents.

Amperes traversing the Iron.	Resistance of the Iron.
0·2	1
0·5	1 - ·000026
2·0	1 - ·000033

The numbers in the second column do not differ from each other more than can be attributed to errors of observation. Such differences as do exist would appear to show that the *more powerful* the current the *less* the resistance, but other trials on subsequent days gave indications, equally slight, in the contrary direction. On the whole, the writer feels justified in assuming, from these and other experiments, that for *steady* currents ranging from ·1 to about 4 amperes, there is *certainly no difference in the resistance of an iron wire apart from that due to change of temperature amounting to one in twenty thousand.*

There is, however, another way of attacking the problem. It would seem to follow from the principle of conservation of energy that if the circular magnetisation, arising from the passage of a current through an iron wire, does produce any alteration in the resistance, this must be in the direction of increase. Now, longitudinal magnetisation would tend to annul circular magnetisation; consequently, if we keep the current through the iron constant and employ longitudinal magnetising forces, by means of a coil surrounding the wire, of gradually increasing amounts, such forces, if very feeble, should produce decrease of resistance in the wire traversed by the current and, if great, increase of resistance. The writer has tried the effect of changing the longitudinal magnetising force, whilst the current through the wire is kept constant, also of a constant longitudinal magnetising force with different current strengths through the wire; and after a very careful investigation, has come to the conclusion that the alteration of resistance produced by a longitudinal magnetising force is not *materially* affected by the strength of current traversing the iron. Of course it must be understood that the currents used, and the time that they are allowed to flow, must be such as not to materially increase the temperature of the wire, otherwise the mere alteration of susceptibility produced by alteration of temperature, will sensibly affect the increase of resistance produced by longitudinal magnetisation.

ELECTROLYTIC THEORIES.*

BY PROFESSOR G. F. FITZGERALD, F.R.S.

Electrolysis has been explained on two different theories by Grotthüs and Clausius. As generally received they differ. Grotthüs' theory, as generally given, assumes that the molecules in an electrolyte are both polarised and moved by the electric forces within the liquid. This seems so far untenable that it would appear that double the electric force would double both the polarisation and the motion of the molecules, and so should produce four times the electrolysis. The objection, however, assumes that we know the causes resisting the motion, and with proper, and not very improbable assumptions as to the resistance to motion depending on it and on the polarisation, a linear relation between current and electro-motive force, *i.e.*, obedience to Ohm's law, seems possible. A modification of Grotthüs' hypothesis in the direction of Clausius' is, however, possible. Suppose that when polarised the molecules *drew one another apart* at a rate proportional to the polarisation. This at once makes the relation between electric force and the decomposition a linear one, and so satisfies Ohm's law in the case of small currents. It also so far agrees with Clausius' hypothesis that it explains electrolysis and double decomposition as properties of the same kind. The molecules in a liquid will occasionally be arranged by accident in the proper polarised condition in a closed circuit for drawing one another apart; and if the circuit includes molecules of different kinds, there will result double decomposition. There seem to be very serious difficulties in supposing that uncombined atoms are for any finite time free in the liquid; and the supposition that it is a particular arrangement that is required before exchanges take place, and that with this arrangement exchanges take place of their own accord, seems to explain electrolysis and double decomposition without supposing free atoms to exist within the liquid. I have not assumed Prof. Armstrong's suggestion that the proper arrangement for double decomposition is a double molecule; but it seems a likely hypothesis, and one that should be investigated from the chemical rather than the physical side.

There are some other phenomena that have been explained upon the supposition that free atoms are gadding about in a liquid. Such are the lowering of the boiling and freezing points by solution of salts, and their effect on osmotic pressure. If dissociated atoms are going about in a liquid as in a gas, it seems impossible but that they must diffuse at different rates; and that this is not observed seems conclusive against the hypothesis, no matter what else the hypothesis may explain. Consider solution simply. Why does chloride of sodium dissolve in water? There must be some strong affinity between the two of a chemical or semi-chemical nature to break up the cohesion of the crystal; and it seems reasonable to assume that this same affinity keeps the molecules of NaCl moving about among the water molecules, so that they diffuse about. Now if the forces drawing them about be independent of the nature of the molecule, most of the phenomena explained by gaseous laws are explained. Pressure of a gas depends, at any temperature, on the number of molecules, and not on their kind. This is Avogadro's law, by which molecular weights are calculated; and if the forces drawing a molecule about in a liquid are independent of the kind of molecule, the very same law of pressure would hold, the pressure forward of molecules of different kinds would depend on their number only, and in the same way as Avogadro's law would enable molecular weights to be calculated. In this connection it is well to state that some bodies may, nevertheless, be much better able to produce pressure than others, because of their being more easily polarised, *i.e.*, turned into an effective direction. A molecule which could be easily turned into an effective direction would be about twice as effective as a molecule which went about in a higgledy-piggledy way; and one would consequently expect electrolytes to produce more, nearly double, the osmotic pressure that other bodies did. As to the changes of boiling and freezing points, they seem explicable by exactly the same hypothesis. The reduction of

* Communicated by the Secretaries of the Electrolysis Committee of the British Association.

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vapour pressure by molecular affinity of dissolved salt would depend only on the number of molecules of salt if all salts have the same molecular affinity for water; and the same would apply to the change in freezing point. Hence all these phenomena are explained without assuming free atoms, and they are all explained by what can hardly avoid being a *vera causa*, namely, whatever affinities they are that cause solution, which latter is an unexplained phenomenon on the dissociation hypothesis. That it is reasonable to think that the forces keeping the molecules of salt moving about in the water are independent of the nature of the salt, appears from various considerations. In the first place, these forces are in all probability due to the residual affinities of the non-metallic elements. These same forces are probably the cause of crystallisation. These are old suggestions. That these residual affinities should be nearly the same for different combinations does not seem at all unlikely.

If a rather shaky argument in favour of its likelihood on mechanical grounds is desired, the following may deserve attention. Suppose a molecule of NaCl, for instance, at rest, or nearly so, in a crystal. Subject it to this affinity. Its velocity, after it has gone a distance, s, will be given by some such relation as $fs = \frac{1}{2} m v^2$. Now, for the sake of temperature equilibrium, with molecules of somewhat similar structure, $\frac{1}{2} m v^2$ must be the same in all. It seems likely that, at least approximately, the kinetic energy of motion is proportional to the total energy, and that this is the same for each molecular group; if so, the kinetic energy must be approximately the same for different groups. Now, with very dilute solutions s must be nearly the same for different molecules, and if so we get that for temperature equilibrium f must be independent of the nature of the molecule. How this equalisation of f for different kinds of molecules comes about may be as follows. Molecules in a liquid move about among one another, but are well within the sphere of one another's attraction, as is evidenced by superficial tension and by the tension to which a liquid can be subject. A very small change in the distance apart of the molecules means, however, a very great change in the forces between them, as otherwise they would be extensible and compressible like gases. It seems likely, then, that when a salt dissolves in a liquid it requires for temperature equilibrium that the distances of the molecules should change by the very small amount required in order that f may become the same for all substances. This very minute change in distance would not sensibly affect s.

NOTES ON THE DIFFERENCES BETWEEN ENGLISH AND AMERICAN ELECTRIC LIGHTING ACCESSORIES.*

Having had the advantage of gaining an intimate knowledge of the methods of construction and the electric lighting accessories in general use at the present time in England, I have naturally endeavoured to compare the ways and means that appear to have been generally adopted with those prevailing in England.

A comparison should not be made without due regard to the prevailing conditions, and I consider that the chief conditions are four in number:—

1. Climatic and characteristic differences. 2. The more general use of electric lighting in the States by the less moneyed classes. 3. That wiring work in the States is mostly done on a "centre distribution system." 4. The keen competition between the three or four leading companies in America.

As regards No. 1, an English electrician's first feeling is one of surprise that installations can be run at all; for, judging from first appearances, it would seem that very little trouble is taken to insure good insulation resistance and safety of the conductors. Wires seem to have been put up just in the quickest and easiest way, and little attention has been given to appearances; in fact, wires often sadly disfigure what would otherwise be called elegant rooms and buildings. Upon asking the reason, one is told that the American electrician "must hustle;" he has not time to "wait and look round;" he wants to get the work done and his account collected. The American is correct, and he is complying with natural conditions; for the American general public is not hard to please in the matter of appearance, and the ways and means are not questioned so long as the end is satisfactorily obtained. Climatic differences operate to a very large extent, and the methods adopted here, even if permitted on other grounds, would fail in England, on account of low insulation resistance.

2. As electric lighting here has come into general use among small stores, saloons, &c., a demand has arisen for cheap work, and artistic fittings are not required: while, owing to the dryness of the climate and the amount of wood used in the interior house construction, the cheap open cleat work with wires run in sight upon the varnished deal ceilings is quite a usual construction, and must evidently give satisfaction, both from the companies' and consumers' point of view. This condition has, I consider, had a great effect upon fittings and accessories, as tending rather to encourage inferior finish and construction, the idea being that low cost of production is all-important. In England we have not reached the time when power supply companies will instal the wires gratis, and the cost of current alone renders lighting a comparative luxury, so that all work is carried out in the better class of house or store, where the owner is prepared to pay a high price for its installation, and paying this price, he naturally becomes very exacting as to the appearance of the work and fittings. This condition, coupled with strict fire-office rules (almost as exacting, from the free American point of view), has combined to improve both the appearance, design, and construction of English accessories and installation work.

3. The "centre distribution" method of wiring seems to be preferred by American electricians, presumably because of the labour saved, as this system is easily and rapidly installed where the work is done on one floor, and long "runs" can be obtained and a conspicuous duplication of wires is no objection. It is urged that a more even potential is obtained by this method, but I believe only from an extra expenditure in copper, for in most cases the "free system" (general in England) gives just as even distribution with a smaller *total* weight of copper installed. The question here is whether copper is not cheaper than labour, for a free system requires additional labour in tapping on the many small distributing branches, and American labour being expensive, it is cheaper to work on a centre distribution system and pay for the extra weight of copper used. A centre distribution system also affects a saving in the number of branch and fuse blocks, not so many different sizes being called for in construction.

4. Owing to the keen and to a certain extent injurious competition existing between the leading companies (each of which has the only successful system) in the desire to bring out and perfect its main features, the details have to some extent been ignored or left to others to perfect or those adopted which have low first cost. Perfection in details can effect great savings in labour and petty annoyances, and often it is the apparently trivial improvements that make all the difference.

Wires.—As regards insulation, usage in America would seem to favour certain preparations and admixtures of rubber in preference to Para rubber, it being found that the dry air and heat have a withering effect on pure rubber, causing it to dry out and develop cracks.

An addition of certain well-known materials, such as sulphur, Trinidad pitch, &c., seems to have a beneficial effect and give a longer and more satisfactory life, while it affords an efficient insulation resistance. The dampness of the English atmosphere acts injuriously on a rubber composition, causing chemical changes and eventually destroying the necessary qualities of mechanical strength combined with insulation. A compromise has accordingly been made, and the construction now finding general favour is a thick coat of pure rubber on a tinned or cotton-coated copper wire, over which is served a double layer of cotton. A prepared rubber mixture is then applied, and this is served with a lapped or preferably braided coating of cotton. The wire is then passed through the vulcanising chamber and finished by being drawn through some tar compound. Positive wires are often soaked in a red lead compound, so that the colour will form a means of distinguishing them from the negatives, as in practice there are many cases when this difference in colour saves time and testing. I would mention that some users complain that the red wire is inferior to the black in point of life and insulation resistance.

The cables used in England for interior wiring work have an average insulation resistance from about 750 megohms (used in good dry positions, between joists, &c.). So 5,000 megohms per mile (used, say, for moulded work in plaster), and the corresponding small wires and leads, would vary from 150 to 500 megohms per mile.

American wire manufacturers do not appear to lay so much stress upon the actual tested electrical figures as upon the thickness of the insulation. To purchase wires according to the thickness of the insulation would be considered somewhat odd in England. But the American has an advantage over the English wire manufacturer inasmuch as he has not to carry such a large and varied stock of sizes; for, owing partly to experience and convenience on the one hand and fire-office restrictions on the other, no solid wires of

* Abstract of article by Fred. Bathurst, Assoc. Inst. E. E., in the *New York Electrical World*.

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a larger diameter than No. 16 B.W.G. are being used in construction work, the required sectional area being obtained by stranding a number of fine wires (3, 7, 19, 37 are the numbers generally found in a strand); and a certain sectional area can either be obtained by stranding 7 wires, or 19 of a smaller diameter, which gives rise to a duplication of stock, for one contractor prefers 7 strands, another the 19 strand cable. Some six or eight different gauges are amply sufficient for ordinary work done on a "centre distribution" method, but many more are asked for when the "free distribution" is used.

Restrictions as to insulation resistance are far more rigid in England than here, for every building wired for electric light is tested, and must be approved by both the Company supplying the current, and the insuring fire officer, and all work must come up to a predetermined standard insulation resistance, usually

2·00	megohms	for a	25	-light	installation.
1·25	,,	,,	50	,,	,,
0·75	,,	,,	100	,,	,,
0·5	,,	,,	150	,,	,,

Here, although, of course, the better installations are tested for actual figures with a bridge and galvanometer. The magneto bell-test seems to be in pretty general use for ordinary work, and it is needless to say that only the roughest idea can be gained by this method, and the magneto only "speaks" when something is radically wrong. I have endeavoured to obtain actual figures for the open cleat-work prevalent here, but have not been able to collect sufficiently exact data to form a comparison. Any one having such figures would do well to publish them, as they would throw a great deal of light on the relative conditions of working.

Switches.—It is supposed that every electrician has at some period of his career improved, designed or invented an electric light switch, and consequently the class and type of the genus switch is legion, and the difficulty of making a comparison is greatly increased; but two or three general points of difference can be seen between English and American switches.

1. Double pole switches are used to a much greater extent here, and are evidently a step in the right direction. Even small 5 and 10 ampere switches are designed to break both poles at once, and in spite of the mechanical difficulty of making a small, neat, and efficient form of D. P. switch, American manufacturers have evidently tackled the problem seriously and obtained satisfactory results.

2. Switches that snap on and off are generally used here. While no one will question the advantage of the "snap off" and its partial elimination of the spark, the advantage of the "snap on" is not so apparent; it prevents children or others from "playing with" and "arcing" the switch so as to obtain the "pretty blue arc," which may possibly destroy the contact surfaces; but, on the other side, the mechanical construction to properly effect this object is imperfect, intricate, or clumsy. A good contact should be both a "grinding" and "sliding" one, and at present we have not this ideal in the "snap on" switch, for either the grinding (owing to the contact pressure) or the "sliding" and cleaning action is only partially carried out.

The mechanical devices finding general favour here are either "cam movements" or "springs working over centres."

3. Place an English type of switch beside the American, and a glance shows a striking difference. The English one only attempts one-half what the American does, but has all the advantage in the matter of appearance, for it seems to have been well designed, with the fewest number of working parts, and has a solid, substantial look about it. The American, on the contrary, seems to contain many small parts, roughly finished and hastily put together, and has evidently had little hand work put on it. Perhaps it is unfair to compare two articles that do not accomplish exactly the same objects, but the illustration will serve to point out the noticeable point that in the English switch considerable attention has evidently been given to appearance.

4. In the smaller switches two sizes seem to be all that are required; while in England 3, 5, 10, 15, and 20 ampere switches are in general use.

Here switch socket holders are provided for nearly every lamp, while in English installation the switch for the room can nearly always be found just by the door, so that any one entering in the dark can immediately light up the room without groping about for the fitting.

5. Many switches seem still to be fitted with wood bases, although generally provided with mica "flash plates." Dry wood is a very efficient insulator, easy to obtain and convenient to work, but is extremely liable to fire. In England slate or porcelain is in general use. Slate, when boiled in paraffin, after having been carefully selected, is fairly reliable, but some slates are far more absorbent than others, and slates from the same quarry often vary greatly in insulation resistance. English porcelain is a very satisfactory material for switch bases.

Fixtures.—In America the gas fixtures are generally used for the attachment of electric lamps and globes, and in England their use is the exception; for owing to the general use of gas the centre of a room is usually occupied by the conventional gas fixture, which, while difficult to adapt, is still more difficult to insulate from earth, and fire officers discountenance the combination. The electrician, therefore, takes to the walls, and by putting in small ornamental brackets or pendant brackets, secures a more even distribution of light with a prettier effect. People using electricity expect more light than from gas, and look for something out of the ordinary, and a tendency has thus arisen to make electric fixtures as different in design as possible from gas fixtures.

American fixtures are generally made with "galleries" for carrying the shade; in England shade-carrying holders are used on account of their being more compact and better and generally superior in appearance.

Lampholders.—A peculiar point of difference is apparent in the respective lampholders or sockets.

Here nearly all are designed upon the plan of having an inner central contact plate surrounded by an outer contact ring suitably insulated from it, and the lamp with cap to suit is either screwed or forced up into the socket. The usual English holder has two contact pillars which are mounted side by side on an insulating base. The pillars have spring contact plungers and make contact on two half-moon plates embedded in the lamp cap; the cap is fitted with small outside pins which engage in bayonet slots. This construction, although, perhaps, slightly more expensive to manufacture than the former, has one or two good points: first, that there is a greater certainty of contact, as the quarter turn (securing the pins in the bayonet slots) gives a rubbing and cleaning action while pressure is applied from the contact plungers; second, there is no tendency to overtwist and break a lamp while inserting it, for the "snap" indicates when the lamp is securely fixed; there is also little chance of a lamp falling out of the socket.

Owing to the almost exclusive use here of switch socket-holders, fixtures have to be placed within easy reach, and are sometimes awkwardly low. The tap or switch-handle makes a shade-carrier on the socket inconvenient, and a gallery preferable. A closed gallery looks heavy and clumsy, while an open one allows dust to collect on the lamp bulb. The English shade-carrying holder is designed to take a shade with a 1⅛in. diameter hole, and the sliding sleeve fits the hole exactly, so that by its use a more graceful combination can be made, and the disadvantages of the gallery excluded.

Lamps.—The monopoly of the lamp industry in England is a sore point with electricians, as having caused users of incandescent lamps disgust and annoyance in various ways, and prevented long-looked-for improvements in efficiency.

Fuse and Branch Blocks.—Some four or five sizes of branch blocks seem sufficient to fill all conditions arising in American construction work, mainly for the reason given under condition No. 3. In England the branch block used here is unknown, because it is not applicable (at any rate from an artistic point of view) to moulding work, its place being filled by two or three patented devices used in conjunction with a large number of fuse boxes. American and English porcelain are very different; the former is vitreous. English porcelain is an earthenware. Its name arises from the fact of its superior white colour and perfect glaze. English porcelain is undoubtedly much easier to work than American, and gives more highly finished work, is not so brittle, and there is no material difference in specific resistance. In these highly insulating materials surface conduction is of greater importance than the slight interior conduction.

The design of main cut-outs and double pole-casing pattern safety junctions is virtually the same, the only difference being that in American practice there is a tendency to clamp the cable between two plain longitudinal surfaces in preference to passing it around a screw head under a washer. English practice is to cover up entirely if possible all metal parts on branch blocks, ceiling roses, fuses, &c., so that there is no possibility of obtaining a shock accidentally. Americans do not seem very particular in this respect. In England magnetic cut-outs have proved very reliable. There must be an excellent opening in the American market for them.

Ceiling Roses.—The American ceiling rose is not an artistic addition to a room, for the reason that some metallic part is uncovered, from the fact that the feeding wire is connected up by clamping it in a jaw or similar device which must stand away from the base. This device, while facilitating erection, would not be permitted in England, where all connections of this sort are made by soldering on a small piece of wire, and bringing the insulation completely within the base.

As the main features of the different systems become better known, and the chief electrical problems solved, more and more attention is being bestowed on the minor accessories, and the system possessing the most carefully worked-out details must eventually secure the lead.

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RAILWAY RATES.

The draft classification of merchandise traffic and a schedule of rates and charges, being the result of the protracted enquiry which was held before Lord BALFOUR OF BURLEIGH and Mr. COURTENAY BOYLE, has been issued by the Railway Department of the Board of Trade. Five separate copies are printed for the five principal railway companies; but we have found on a careful examination that in so far as they concern the electrical trades, these are identical. When this important matter was first brought before the Electrical Trades Section of the London Chamber of Commerce, we printed at length long list (*The Electrician*, May 17th, 1889) of all the items that could possibly concern the electrical industry. These were extracted from a schedule deposited by the Railway Companies' Association with the Board of Trade. The matter was at once taken up, and a committee was appointed, on which it is no secret that Mr. GARCKE did all the work. The articles marked for objection are given in another column.

Thanks to the organisation of the London Chamber of Commerce, the objections were dealt with in a systematic form by a firm of solicitors. The classification, as most of our readers are aware, consists of eight classes—A, B, C, 1, 2, 3, 4, 5, A being the lowest rate, and comprising coal and ore, &c., in four-ton lots, and 5 the highest, for expensive or fragile goods. On the objection forms for each item were given (1) the class proposed by the Companies in the Deposited Schedule; (2) the class proposed by the objector; (3) the class in the Clearing House classification. The objections were set out, and reasons were given for the objections of the traders. These were sent to the Companies, who appended a

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reply to each, either defending their claims or conceding the classification proposed by the objectors. A most careful watch had to be kept for tricks. We impute no fraud whatever, or even shabbiness; but there are tricks in every trade, which are recognised by a certain code of morality as tricks.

A case in point was that of "telegraph insulators." These were Class 1 in the Clearing House list, and were omitted in the Deposited Schedule. The Chamber of Commerce objected to the omission, since, not being specifically mentioned under any other class, they would be liable to be charged at the highest rate as Class 5. The Companies' reply was that these were covered by the wider term "electric" insulators; and added, "There is no reason why 'telegraph' insulators should be classed lower than 'electric' insulators, as some of the telegraph insulators are of very considerable value." Now, no objection had been taken to "electric insulators" in Class 2, as it is difficult to say what the term means, and having lodged no objection, there might have been a technical difficulty in dealing with the matter. But the inquiry was conducted in so careful and impartial a manner that every facility was given for explanation and definition, and in this case the Board of Trade recommend that "telegraph insulators, earthenware packed," should be in Class 1, and electric insulators in Class 2. The curious distinction between "electric storage batteries" placed in Class 3, and "electric accumulators" in Class 2 as given in the Deposited Schedule, was not supported by the Companies; the latter description and class only are adopted. We need not recapitulate the arguments which were made at the inquiry on the other items, as the proceedings were reported more or less fully in our columns at the time. The objections to omission drew from the Companies definitions and classifications, as, for example, the important article "dynamos," which it is decided goes as "machinery," and the unimportant "sponge cloth" which will go as "cotton and linen goods," but which, had it not been for the objection, might have had to go under "millinery" or "sponges" in Class 5.

On the whole, the electrical trade is to be congratulated on the result of the inquiry, and they have to thank the Chamber of Commerce, where a special staff was engaged under Mr. Musgrave, who worked at nothing else for months. It is rather remarkable that so little interest was taken in the matter by the electrical trade generally, and still more singular was the complete indifference of certain other trades, who either failed to give sufficient instruction to their representatives, or in some cases neglected to put in any appearance. In one or two cases, such as those relating to iron and steel castings, sheets, &c., it was considered that the electrical trade would be safe if the matter were left in the hands of others; but the results are not very satisfactory.

"Castings (iron or steel) light, in boxes, cases, crates, casks, or hampers" were proposed for Class 1; but they are placed in Class 2. Perhaps that is fair, but "castings, steel e.o.h.p., that is "except otherwise hereinbefore specified," are placed by the Board of Trade in Class 3, together with "castings, iron, light, e.o.h.p." We find no mention of the important item of sheet iron, except in Class B, which is for consignments of four tons and upwards. The Companies agreed to adopt Class 1, as proposed by the Chamber of Commerce. Nor do iron telegraph poles appear except in Class B. The two most successful results of the objections raised by the electrical trades, if the classification of dynamos, which was a formal matter, be excepted, were "telegraph cable" and cotton-covered wire. The Companies asserted that the former was "frequently coiled on to the waggons and uncoiled for delivery." They were unable to give a single instance when challenged to do so; and the Class 3 which was asked for has been granted by the Board of Trade. Cotton-covered wire, which no electrician can dispense with, was placed in the deposited schedule in Class 4; but Class 2 was allowed, since it is a raw material, and but little liable to damage, It would have been impossible to have carried these points without the assistance of the London Chamber of Commerce, unless a special association or committee had been formed for the purpose, and this would have entailed upon its members a great deal of work which is a matter of routine with the organisation which is so ably headed by Mr. Kenric Murray. Those firms who have not joined the Chamber will reap the benefits of its work, and they may without much difficulty reckon the amount which they will save under the proposed classification. This should be an inducement to support an association which is weak merely in the number of those who attend the meetings, and which may any day have to cope with matters even more important to the electrical trades than are these Railway Rates.

ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 353.)

§ 9. **Transformer Station at Leghorn (Livorno).**—At Leghorn there is a central station in the Via Costanza, on the same general plan as that at Rome, for distribution of electric energy by means of transformers. The plant was constructed by Ganz, and the machines and regulating apparatus are similar in general design to that described in the foregoing sections. A general view of the machine-room is given in Fig. 28. There are at present (1890) three combined engines and dynamos in position. The engines are direct-acting, high-pressure single-cylinder engines of 150 horse-power, fitted with centrifugal spring governors, the governor wheels forming also the pulley by means of which the excitors are driven. These engines are coupled direct to Ganz alternators of the A type, similar in design to those at Rome. The alternators furnish at maximum load a current of 40 amperes at 2,000 volts, and are therefore 80 kilowatt machines. The dynamos are driven at a speed of 250 revolutions per minute. The armatures have 20 fixed bobbins, and the revolving field-magnets 20 bobbins; hence the current has 5,000 alternations per minute, or 42 complete periods. The armature frame rests on a massive bed-plate, on which is also erected the engine; and the arrangement of slotted bed-plate and screw before described renders it possible to traverse the armature away from the field-magnet, and get at it for repairs. Both the field-magnet cores and the armature coil cores are built up of laminated iron plates. There are three such steam dynamos placed side by side; they take steam from a battery of three Babcock and Wilcox water-tube boilers, each of 150 horse-power size.

The excitors are driven off the governor wheel of each engine, and each furnish an exciting current of 25 amperes, at an E.M.F. of 100 volts.

The alternating current furnished by the dynamos is employed to feed about 2,000 incandescent lamps of 16 candle-power. From the station proceed two primary circuits, each consisting of a pair of insulated overhead copper conductors of 28 square millimetres in cross sectional area. The primary current supplies 17 transformers of 7·5 kilowatt size, four of 3·75 kilowatt size, and one of 1·875 kilowatt size, having their primary circuits arranged as usual in parallel between the primary mains. Although the station is not a large one, it is interesting from the fact that the alternators are worked in parallel on a single primary circuit as a regular thing. The two primary circuits start from a switchboard, which is exceedingly well

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arranged. The various connections on it are all made by highly insulated rubber-covered copper wire, carried on porcelain insulators, and the switches, cut-outs, &c, are all on porcelain bases, and have porcelain handles or covers. At one side of the switchboard (*see* Fig. 28) is a bank of 1,320 incandescent lamps. The usual voltmeters, amperemeters, and regulators, are conveniently placed. The automatic mercury cup resistance described in a previous section is also employed to maintain a constant potential at some point on the primary circuit, irrespective of the outgoing current. Each dynamo and engine can carry a load of about 1,200 16 candle-power lamps. When, therefore, the load on the external circuits does not exceed this, or equivalent to about a primary current of 30 amperes, the two separate primary currents are worked as one circuit on one machine. After midnight, when the load generally falls to less than 300 lamps, it is taken over by a small auto-excited alternator, worked by a separate small engine. When, however, the demand exceeds 1,000—1,100

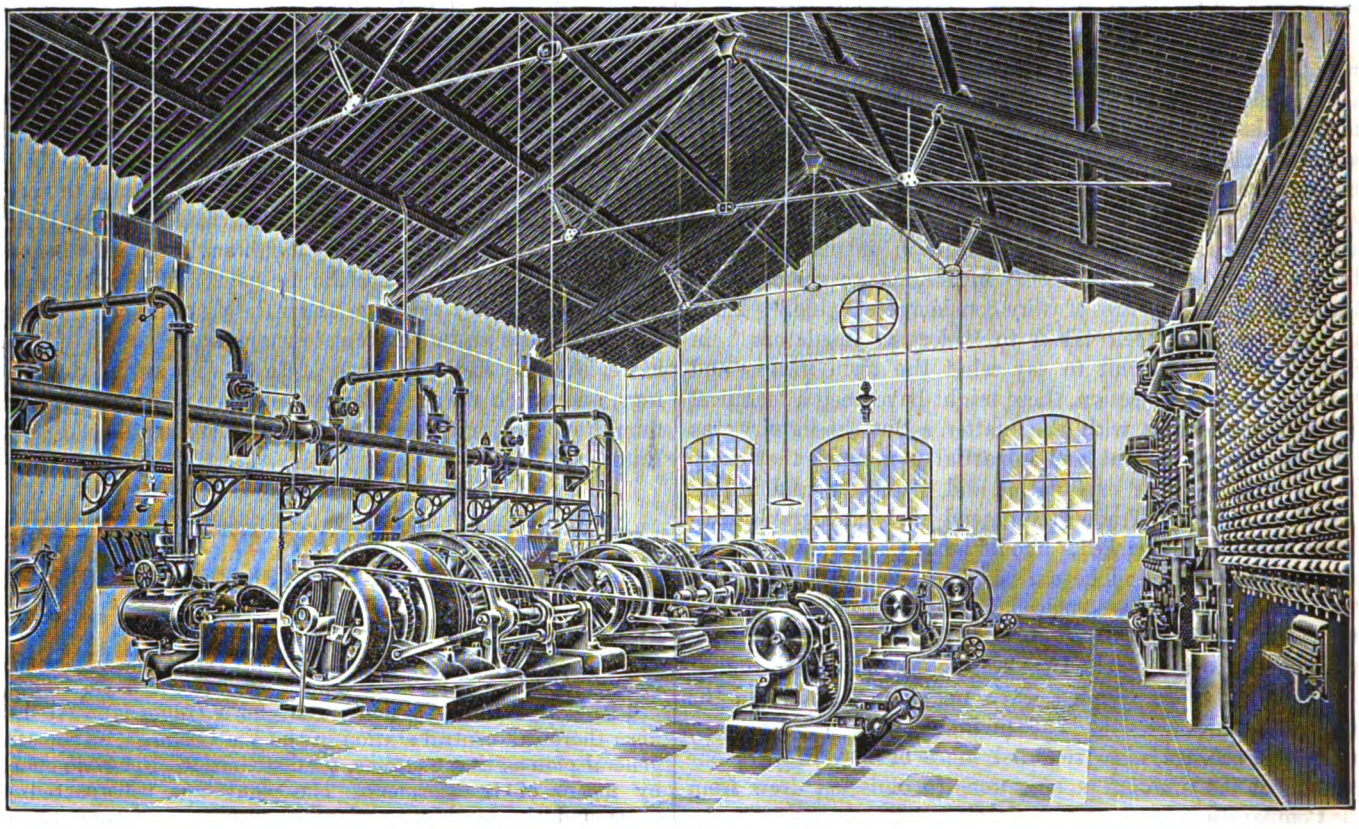

FIG. 28.—View of Central Station, Leghorn.

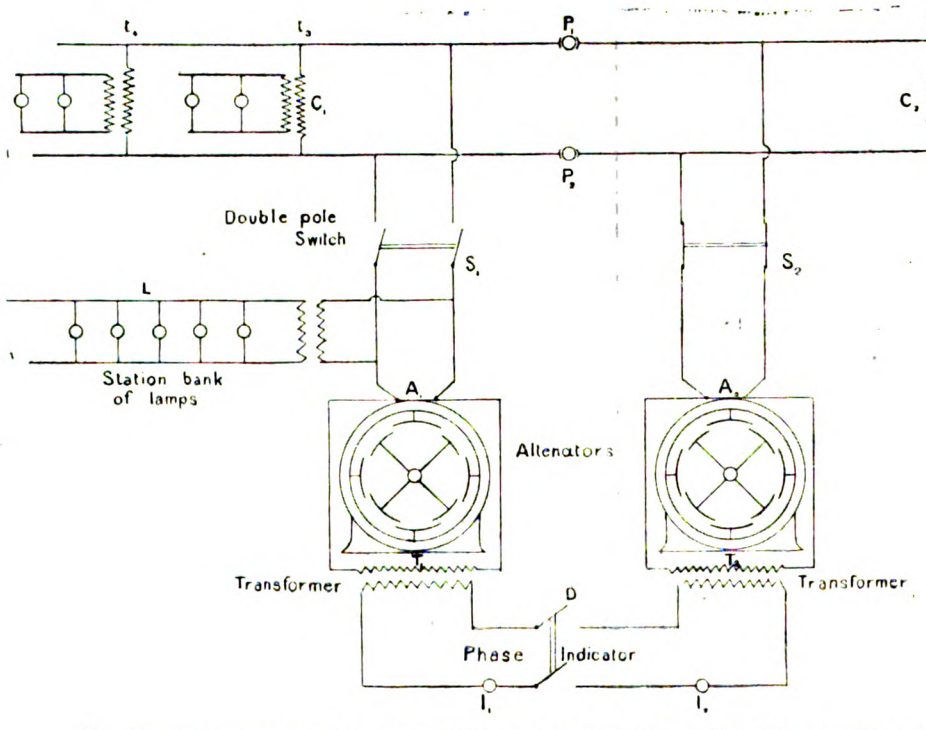

FIG. 29.—Diagram representing phase-indicating arrangement for putting alternators in parallel on one united circuit.

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lamps, two of the larger machines are worked in parallel on to the two primary circuits joined into one. The method by which this parallel working of the alternators is practically carried out is very simple. Let C_1 and C_2 (Fig. 29) be the two separate primary circuits, which may be supposed to be joined into one circuit by the plugs P_1 P_2. Let one alternator, A_2, be supposed to be working on this single circuit, and that the time has come when a second alternator, A_1, has to be added in parallel with the first one to support the lamp load.

The first step is to run up the alternator A_1 to the proper speed and to set it to work on the station bank of lamps L and adjust its E.M.F., so that it has the same electromotive force and current output as the dynamo A_2 already on the circuit. From the poles of each alternator proceed leads to a pair of transformers T_1 T_2 whose secondaries are joined in series through a couple of incandescent lamps l_1 l_2. On closing the double pole switch D the transformers T_1 and T_2 work together on the pair of lamps; and according as the alternators A_1 A_2 are in similar or in opposite phase as regards electromotive force, so are the lamps l_1 l_2 extinguished or alight. The moment when the lamps l_1 l_2 are both out the two machines A_1 A_2 are in step, although on different circuits. As the machines pass out of step the lamps l_1 l_2 pulsate in brightness, producing luminous "beats" as the current pulses catch each other up. At the instant when the indicating lamps are not visibly luminous the double pole switch S_1 is closed. The dynamo A_2 is then in parallel with A_1 on the circuit C_1 C_2; the load of lamps on L is then removed little by little and the two alternators A_1 and A_2 are finally left working on one circuit. Similar arrangements allow all three dynamos to be put in parallel. At Leghorn it is found to be very easy to throw in one, two, or three alternators in parallel as the lamp-load varies, and the machines keep each other in step perfectly when once they are put in parallel.

The station, as will be seen from the view in Fig. 28, is a one-story building, and consists of two rooms, one the boiler-house, and the other the dynamo-room. The station was opened in October, 1889, and has been in successful operation ever since. The station covers an area of about 45ft. by 100ft., and the present building can accommodate one more 150 horse-power engine, boiler, and dynamo, having, therefore, a capacity when full for three active dynamos and one reserve, or an effective output of 240 kilowatts, or 4,000 16 candle-power lamps in full use and for about 6,000 such lamps installed. This station is exceedingly well arranged; and as an example of alternators worked regularly in parallel is an interesting illustration of theory carried out into effective practice.

(To be continued.)

THE KENSINGTON COURT STATION.

The fact that the current has only once been off the mains of this station since the start was made in 1887 cannot but inspire a feeling of confidence in the steady supply which is provided in this district. It will be remembered that not long after the station was started a steam-pipe burst, and the attendant lost his nerve. The dynamos were stopped, and the supply carried on by the accumulators. An amperemeter which happened to be in the battery circuit was destroyed by the large current passing through it; but this did not extinguish the circuits beyond one minute, the attendant having only to turn a switch to cut out the amperemeter, the most noticeable defect being the fall of pressure below the standard amount after the accumulators had been at work for some time. The whole affair did not last more than three-quarters of an hour, during half an hour of which the E.M.F. supplied was 10 to 15 per cent. below the 100 volts. As this, the sole case, happened in the afternoon, very few persons were aware of the stoppage; and so, as far as the supply company is concerned, the consumers have been practically free from those annoying accidents or mismanagements by which the lights of most other supply companies in London have been extinguished from time to time; and those sudden blinkings due to changing over, which many station attendants believe are quite unnoticed, are here unknown. The old engine-room at Kensington Court is hardly to be recognised, it having been thrown into the fine building which now contains the machinery. Three Babcox-Wilcox boilers, each of 250 horse-power, with double steam drums, are placed at the back, behind a partition, which keeps the rest of the room clean and cool. Two of these are under steam at a time, and work at 150lbs. pressure. Four Willans and Robinson 200 horse-power central valve compound engines occupy the middle of the floor, and to two of these are coupled Crompton shunt-wound dynamos of an output of 120,000 watts. Besides these are three 90 horse-power smaller engines and dynamos of 55,000 watts output. The principal switch-board is placed in a gallery, and is of a very complete character, providing for every possible combination of connection with the dynamos, batteries, and mains. One large and two of the smaller dynamos were at work when we visited the station at about half-past ten on Friday last. The engines for silence, and the dynamos for sparkless collection and coolness, were all that could be desired. Two of the larger engines are now awaiting their dynamos. When these are in place, the plant will be sufficient to supply 30,000 lamps. At present there are 19,000 lamps on ten miles of mains of the two Kensington and Knightsbridge stations. The greater part of the new batteries are on the first floor, and are arranged in a very substantial manner. There is, in addition, a battery station in the Queen's Gate district, about half-a-mile from the Kensington Court station. This is principally used as a reserve and transformer station in connection with the Kensington Court station, from which the two large batteries are charged in series, and discharged on to the three-wire system. In a small room a number of meters are being tested, some of them being apparently more ingenious than trustworthy.

The Aron meter is the one in general use, and it gives satisfaction to both parties. It is found in winter that the aggregate amount of current registered by the house meters throughout the district agrees within five per cent. with the main current as measured in the station, a result which few, if any, gas works or waterworks can show, and which has, as far as we are aware, been unapproached by any electric supply station. The Aron meters are not sent out in the condition in which they are received, as has been done by other companies, but they are carefully timed for a fortnight at the station, and then tested with the current. They are then timed for two or three days in position in the consumer's house. Final adjustment is sometimes found to be required. One highly ingenious meter contains an electric clock, in whose works certain springs are liable to go wrong. One of these having been put up in a house, the inhabitants were aroused in the middle of the night by an alarming knocking and rattle which proceeded from the meter, which is said to have made sleep impossible.

Scoffers have averred that since the current is always on the line the engineers cannot know the insulation resistance of the mains. The method of testing is as follows:—At frequent intervals during the day and night the ends of the mains in the station are put to earth through an 8 candle-power lamp. If the lamp glows perceptibly, it is known that there is a leak of a fraction of an ampere on one main; if it glows brightly, there is a more serious leak. At a quiet time of day, either at about noon or at about four o'clock in the morning, the current is turned off the particular main for an instant, and a rough localising test is made. Then the testers proceed to the nearest junction box, and another test is made. It is necessary in rare cases to give notice to two or three houses that the current must be shut off for a few moments to make a test; but, as a rule, the engineers have no difficulty in finding the right house. The leaks are due sometimes to bad wiring, or to accidental overflow of water, or occasionally to some tampering with the wires. Experience has shown that leaks do not develope suddenly, and allow the main fuse to go, as suggested by Mr. Mordey in the discussion on Major Cardew's recent Paper. On the contrary, it is very rare to find a main fuse melted, unless a meddling butler tries to manipulate the mains with a pair of pliers, when he finds that there is plenty of time to

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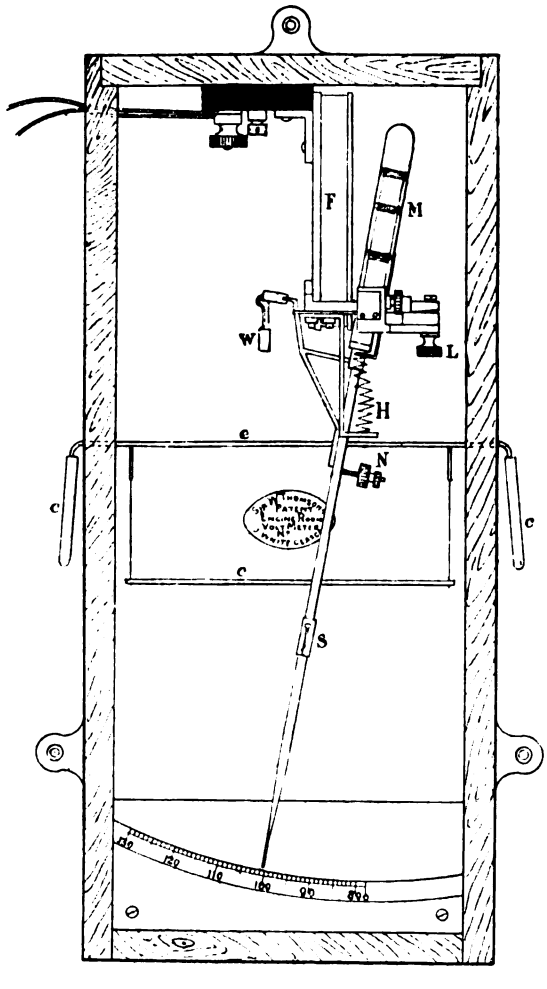
burn his fingers before the cut-out has acted. This individual takes so great an interest in the electric lighting, that he carefully takes out all the cut-outs (of the screw plug pattern) before a dinner party, and smartens them up, and then with less care replaces them in the wrong holes. The supply company is, of course, blamed when the lamps light up for an instant and then cease to burn.

In pushing our inquiries on the subject of leaks, we learned that a lead-covered cable, on which no leak existed that could be detected by the lamp test, suddenly broke down, and on examination it was found that the cable which was imbedded in brickwork had been earthed through a high resistance, and an electrolytic action, which had evidently gone on for several months, had eaten away the conductor. The fault lies in using and relying on lead-covered cables which may be called of the "dry insulation pattern"—that is, the insulation only remains good as long as the lead is perfect; but if water gets through the lead cover, the insulation slowly breaks down. Luckily this defect was soon found out, and very little of this kind of cable has been used. These accidents, however, are very rare, and there are not yet enough on record to enable any particular conclusions to be drawn from them.

SIR WILLIAM THOMSON'S NEW ENGINE-ROOM VOLTMETER.

Sir William Thomson's new engine-room voltmeter is intended for installation work on either direct or alternating circuits,



where it is convenient to have a direct-reading voltmeter with large scale divisions. The instrument, as shown in the figure, depends for its action upon the repulsion of a movable coil, M, by a fixed coil, F. The fixed coil, F, bears all the other portions of the instrument attached to it, and is in its turn supported from a vulcanite block fixed to the instrument case. This vulcanite block also bears the terminals of the instrument. The movable coil is supported on knife edges, and the circuit through it from the fixed coil of the voltmeter is made by two spirals of fine copper wire. A pointer attached to the movable coil indicates by direct readings in volts the difference of potential between the terminals of the instrument. Attached to the pointer on one side, and perpendicular to it, is a short arm, with a screw nut, N, which, together with the sliding weight, S, on the pointer, serves to adjust the balance of the movable parts. To the other side of the pointer is attached a bracketed arm terminating in a knife-edged stirrup, on which is hung the weight, W, fixing the constant of the instrument. The movable coil can be lifted from its bearings by turning the screw, L, which raises a lever passing below the knife-edge trunnions, and so fixes the movable portion of the instrument when the instrument is being removed from place to place, or is packed for carriage. A checker, *c c*, is provided to facilitate the taking of readings when the circuit is for some reason being made and broken, or the potential being suddenly and largely varied.

The instrument is graduated by direct comparison with a standard centi-ampere balance. The movable portion is first adjusted to be in neutral equilibrium by means of the sliding weight, S, and the nut, N; the weight, W, is then hung on the knife-edged stirrup. This weight causes the pointer to come to zero, in which position the movable coil is pressed against the fixed one. The scale consists of very nearly equal divisions, and is usually graduated from 80 or 90 to 140 or 150 milliamperes. The coils of the instrument are wound with many turns of copper wire, and have a total resistance of about 100 ohms. An anti-inductive resistance of platinoid wire, fixed to the back of the instrument, is adjusted to make up with the resistance of the coils 1,000 ohms at a given specified temperature; thus, as the scale is in milliamperes, the instrument reads directly in volts.

THE WORKING EFFICIENCY OF SECONDARY CELLS.*

By W. E. Ayrton, C. G. Lamb, E. W. Smith, and M. W. Woods, Associates.

(Concluded from page 347.)

IX.—*Resistance.*

The resistance in ohms of an accumulator when charging and discharging is given respectively by

$$\frac{V-E}{A}, \text{ and } \frac{E-V}{A},$$

where V is the potential difference in volts at the terminals when a current of A amperes is passing, and E is the E.M.F. of the accumulator at the moment V is measured. To measure E the main circuit is broken, and the potential difference observed as quickly as possible. On breaking the circuit, however, the deflection of the voltmeter does not sharply change from the value that measured V to another definite value that measures E; but, on the contrary, as seen from Fig. 4, in consequence of the fall of the E.M.F. of an accumulator on breaking the charging circuit, and in consequence of a similar rise in the E.M.F. on breaking the discharging circuit, the voltmeter deflection continues to vary for several minutes after the circuit is broken. Hence the value of E, measured by a voltmeter which is not infinitely dead-beat, must be too small during charging, and too large during discharging; and consequently, since the above formulæ for the resistance are only true when V and E are the simultaneous values of the potential density at the terminals of the accumulator and of its E.M.F., it follows that the resistance has hitherto been measured too large both in charging and discharging.

The magnitude of the error that has been thus made in different experiments depends, of course, on how dead-beat a voltmeter was employed, and, consequently, on how long a time was allowed to elapse between the breaking of the main circuit and the taking of the reading. For example, we find that towards the end of the charge with the normal current of 9 amperes the E.M.F. varies about one per cent. in 20 seconds after the circuit is opened. Now, as the difference between V and E which measures

* Read at the Extraordinary General Meeting of the Institution of Electrical Engineers at Edinburgh, on July 16th, 1890.

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the resistance, is only of the order 0·1 volt when it has its maximum value during the normal charge or discharge,—that is, of the order four per cent. of E—it follows that an error of one per cent. in the measurement of E would make an error of about 25 per cent. in the measurement of the resistance.

To measure the resistance accurately we ought to be able to measure the difference between V and E to one-thousandth of a volt, and, therefore, as E is about two volts, the voltmeter must be very sensitive with a long, open, scale, and the needle must move through a considerable angle; whereas, in consequence of the rapid variation in E, the voltmeter must be very dead-beat—a condition almost incompatible with a long range and great sensibility.

These two conditions, however, we have fulfilled by the employment of the following device, by means of which the difference between the values of V and of E was measured to the one-thousandth of a volt at identically the same moment that the values of V and A were measured. The process was as follows:—

1st. The sensibility of the voltmeter was adjusted so that 12 volts produced a deflection of 600 divisions, and V, the potential difference at the terminals of the four accumulators under test, was measured.

2nd. A compensating E.M.F. was introduced into the circuit just sufficient to bring the spot of light to zero.

3rd. The sensibility of the voltmeter was increased 60 times.

4th. The main circuit was broken, and the time variation of E, the E.M.F. of the accumulators under test, observed by noting the position of the spot of light at the successive ticks of a metronome, whose rate of going was before each experiment carefully adjusted by comparing the metronome with a chronometer.

5th. A time curve for the values of E was drawn, and by producing it back until it cut the line passing through time 0—that is, the time when the main circuit was broken—we obtained the value of E at the same moment that the values of V and A were measured.

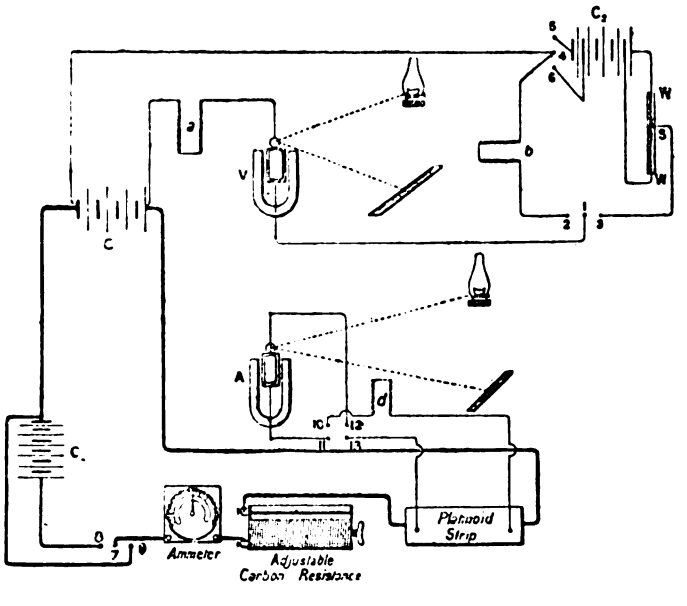

FIG. 10.

The apparatus employed is symbolically shown in Fig. 10. C_1 are the four accumulators under test; when they were being charged by means of the accumulators C_2, a bridge-piece was placed so as to join the mercury cups 7 and 8; whereas, when C_1 were being discharged, mercury cup 7 was joined to 9 instead of to 8. In both cases the current passed along the thick lines through an A. and P. magnifying spring ammeter, whose indications furnished an approximate measure of the current, through an adjustable carbon resistance and a platinoid strip which could carry the maximum current, 10 amperes, used in these tests, without its resistance being perceptibly altered. To two points of this strip were soldered two wires going to the mercury cups 10 and 13; these were joined respectively to 11 and 12 in charging, and to 12 and 11 in discharging, so that the current always went through the D'Arsonval galvanometer A in the same direction. This galvanometer then measured the charging or discharging current, its sensibility being such that for a current of 9 amperes passing through the circuit a deflection of 600 scale divisions was produced when the resistance in d was 185 ohms, that of the galvanometer A itself being 52 ohms.

By joining the mercury cups 1 and 2 with a bridge-piece, the potential difference between the terminals of the accumulators under test, C_1, could be measured with the voltmeter V; the sensibility being such that with a resistance of 791 ohms in a, and 63,696 ohms in b, a deflection of 600 scale divisions corresponded with a potential difference of 12 volts. By connecting the mercury cup 1 with 3 instead of with 2, the resistance b was cut out of the circuit, and the sensibility of the voltmeter V was increased 60 times. If now 4 were connected with 5 or with 6, and the sliding contact S moved along the thick wire WW, a point could be found such that no current passed through the voltmeter V. Next, the main circuit indicated by the thick wires was broken, when the spot of light would move quickly across a portion of the scale, and then continue moving right across the rest of the scale. The first part of this motion was of course due to the sudden variation of the potential difference at the terminals of the accumulators C_1 on the current through them being stopped, while the continuation of the motion was due to the subsequent variation of the E.M.F. of these accumulators after the current was stopped. And the value of the E.M.F. at any moment was equal to

$$V \pm \frac{0{\cdot}2\,d}{600},$$

where d was the deflection of the voltmeter spot of light at the moment in question, and V was the potential difference between the terminals of the cells C_1 just before the main circuit was broken, and which was measured by the voltmeter deflection when mercury cup 1 was connected with 2. In discharging the + sign was, of course, used, and in charging the — sign.

This potential difference at the terminals of the four accumulators under test, C_1, and which had to be balanced by the E.M.F. of the accumulators C_2, approached 9·6 volts towards the end of a charge, while it fell to 7·6 volts at the end of a discharge. In the former case the E.M.F. of four cells and a portion of the fifth of the compensating accumulators C_2 was employed, while in the latter the E.M.F. of three and a portion of the fourth sufficed. Hence, during the charge mercury cups 4 and 5 were connected together, while during the discharge it was 4 and 6 that were connected together. The portion of the E.M.F. of the last of the compensating cells was, as shown in the figure, obtained by shunting this cell through a platinoid wire, WW, of about 2 ohms resistance, and making contact with a point of this wire farther from, or nearer to, the positive pole of this cell. This adjustment of the position of S caused very little change in the resistance of the voltmeter circuit, because the resistance of WW was but a small portion of the entire resistance in the voltmeter circuit.

This method of measuring the resistance of accumulators was applied by three of the students of the Central Institution—Messrs. Müller, Stephens, and Wightman—to determine the variation of the resistance during the entire discharge of the cells with 10 amperes, and charge with 9; further, during May and June of this year Mr. Müller has, with great perseverance, been making an uninterrupted series of observations, day and night, to determine the resistance during the entire discharge and charge for various currents. For each of these currents the cells are being brought to a steady working state by many discharges and charges being successively and without interruption made with each current. In the case of the small current the time of a charge and discharge is tediously long, the charge, for example, with three amperes requiring 40 hours to raise the potential difference from 1·9 to 2·4 volts per cell, so that several weeks have to be spent obtaining the resistance for this current. This investigation of resistance is not yet completed, and therefore we do not propose in this Paper to refer to the variation of the resistance of a cell with different currents when the cell is brought to a steady working state for each current. Such an experiment has not, as far as we are aware, ever before been attempted with accumulators, former observers having contented themselves with merely observing the variation of the resistance when the current during discharge or charge was abruptly changed from one value to another. This is a very different thing from ascertaining how the resistance of an accumulator varies with the current when each of the different currents employed is steadily used for some weeks in the discharging and charging of the cell, until the cell has arrived at a steady working state for the current in question.

We give in Fig. 11 an example of the time fall of the E.M.F. on breaking the circuit for eight periods of 20 seconds during the charge. The curves are all drawn to the same scale, but, in order to get the curves into a reasonable space, a different zero line has been employed in drawing each curve. The actual E.M.F. in volts per cell is given for several points on each curve, so that the time rise at any period of the charge can be easily seen. The E.M.F. at the moment of breaking the circuit in each case is, as already explained, obtained by seeing at what point the curve cuts the vertical line through the time 0. The value of this point in volts is, in fact, what an infinitely dead-beat voltmeter would indicate immediately after the circuit was broken. It will be observed that the time fall of E.M.F. on breaking the circuit becomes more and more rapid as the charge continues.

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The top curve in Fig. 12 gives the potential difference at the terminals of one accumulator, charging with nine amperes; while the second curve gives the simultaneous values of the E.M.F., being, in fact, the curve drawn through points whose abscissæ are the times—0 hr. 37 min., 1 hr. 36 min., &c.—for which the eight curves on Fig. 11 are drawn, and whose ordinates are the values of the points where these curves cut the vertical line drawn through the zero of time in Fig. 11, or time when the charging circuit was broken. The lowest curve on Fig. 12 gives the resistance of the cell at any moment during the entire charge with nine amperes, the ordinates of this curve being calculated from the formula

$$\frac{V - E}{9}$$

when V and E are values of the potential difference and the E.M.F. of the cell at the same instant.

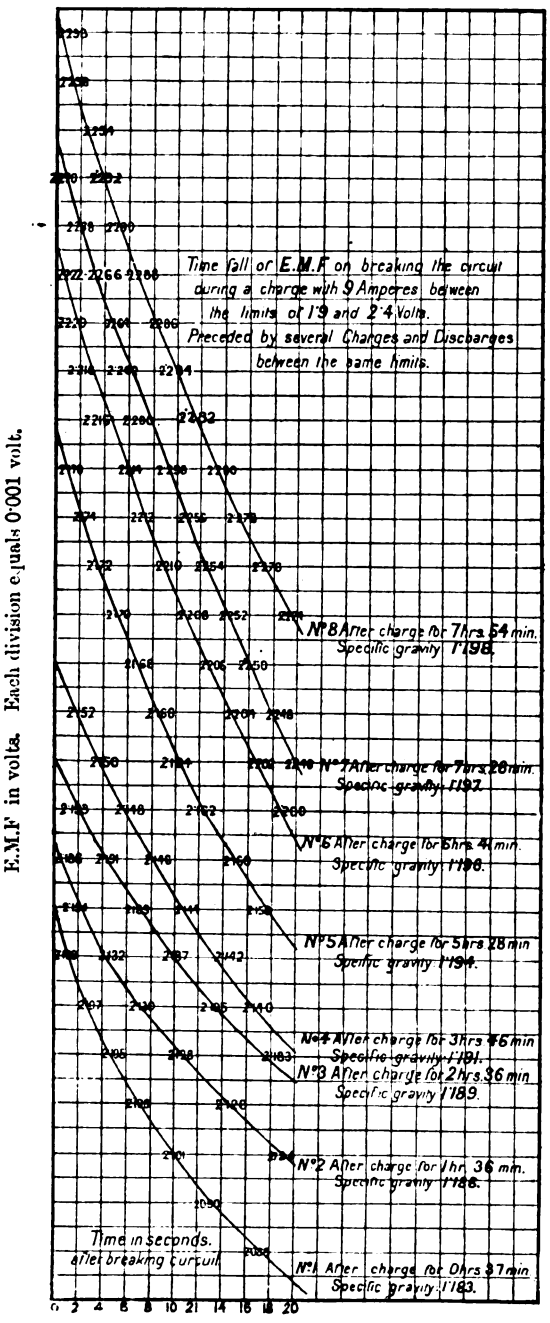
E.M.F in volts. Each division equals 0·001 volt.
Time fall of E.M.F on breaking the circuit during a charge with 9 Amperes between the limits of 1·9 and 2·4 Volts. Preceded by several Charges and Discharges between the same limits.
N°8 After charge for 7hrs 54 min. Specific gravity 1·198.
N°7 After charge for 7hrs 26 min. Specific gravity 1·197.
N°6 After charge for 6hrs 41 min. Specific gravity 1·196.
N°5 After charge for 5hrs 28 min. Specific gravity 1·194.
N°4 After charge for 3hrs 46 min. Specific gravity 1·191.
N°3 After charge for 2hrs 36 min. Specific gravity 1·189.
N°2 After charge for 1hr 36 min. Specific gravity 1·186.
N°1 After charge for 0hrs 37 min. Specific gravity 1·183.
Time in seconds after breaking circuit.

FIG. 11.

positive plates, each surface of which is $9\frac{1}{4}$ into $9\frac{1}{4}$ inches, and that all four surfaces are equally active, it follows that the mean resistance of the 1888 E.P.S. type of cell while charging with the maximum current density allowed—viz., 3·787 amperes per square foot—is about 0·11 ohm per square foot of positive plate.

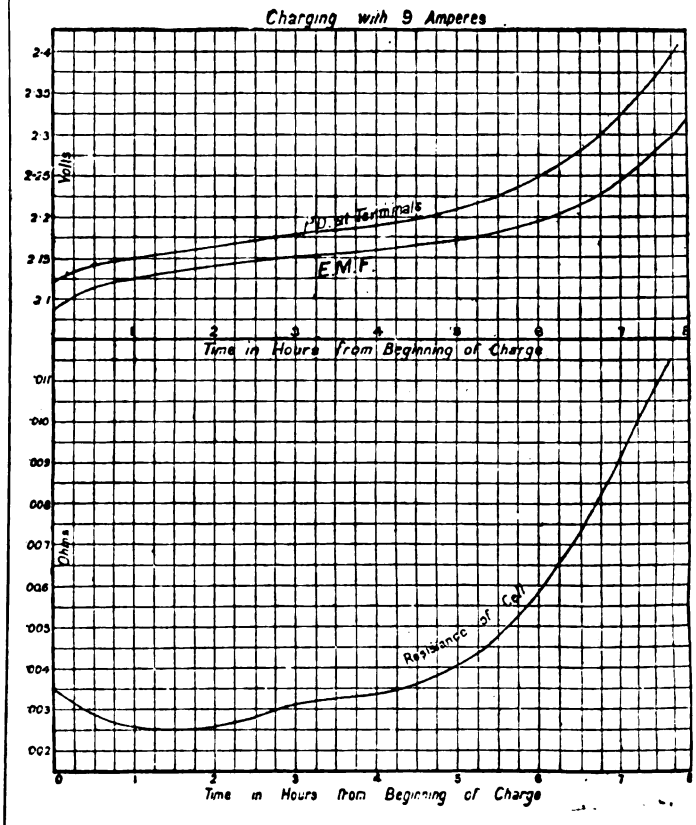

FIG. 12

Fig. 13 gives the potential difference at the terminals of one of the cells during the whole of a discharge with 10 amperes, the simultaneous values of the E.M.F. and of the resistance. The resistance at the commencement of the discharge is a little higher than at the commencement of the charge, and the minimum

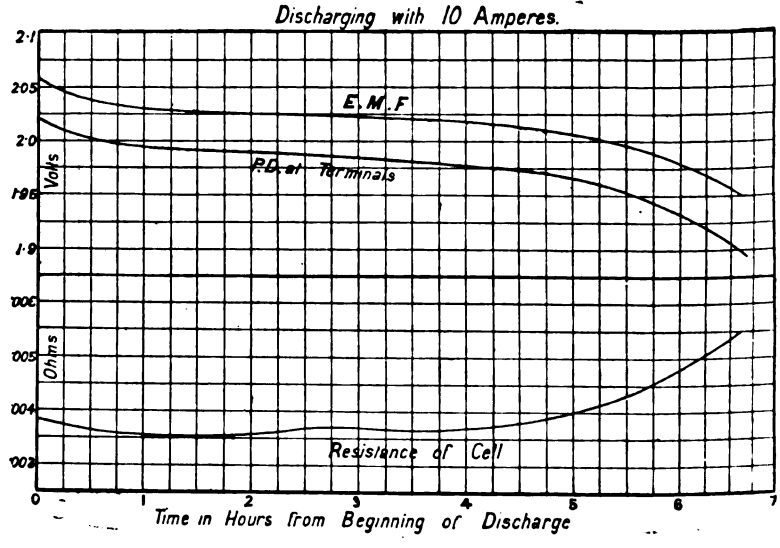

FIG. 13.

As the charging proceeds the resistance of the accumulator at first falls, and reaches a minimum; it then increases, at first slowly, but as the charging approaches the finish the resistance rises very rapidly, so that when the potential difference per cell is 2·4 volts the resistance is five times as great as its minimum value, which is reached shortly after the commencement of the charging. Taking 0·045 ohm as the average resistance during charging, and remembering that there are in these cells two

value to which it diminishes is not as low as the mimimum attained by the resistance in charging. At the end of the fifth hour of discharge and charge the resistance is practically the same. After tha, however, there is a marked difference: the resistance in dischar ing does not rise as rapidly as in charging; and hence, since, in addition the time of a discharge is necessarily less than of a charge, the resistance never reaches as high a value in discharging as in charging.

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If we take 0·038 ohm as the mean resistance during a discharge with 10 amperes, then it follows that the mean resistance of the 1888 E.P.S. type of cell while discharging with the maximum current-density allowed—viz., 4·208 amperes per square foot—is about 0·09 ohm per square foot of positive plate.

Both in charging and in discharging with constant currents, the greater part of the time variation of the potential difference at the terminals of an accumulator is due to an actual variation in the E.M.F. itself; and it is only towards the end of the charge and of the discharge, when the resistance of the cell becomes relatively large, that the slope of the potential difference curve becomes practically different from that of the E.M.F. curve.

We may mention, in conclusion, that the results which we have obtained with accumulators made to go for long periods through definite cycles in charging and discharging, have been so interesting that we are now engaged on the design of an apparatus which will automatically keep the current constant for any time at any pre-arranged value, which will automatically change over from charge to discharge, or from discharge to charge, when the potential difference per cell reaches any pre-arranged limit, and which will record the potential difference at the terminals of the cell, and also its E.M.F. during the whole period.

We hope, therefore, at some future period to be able to present a graphical record of the life-history of accumulators from their first formation to their death.

[The discussion which followed the reading of this paper will be given in our next issue.]

LONDON CHAMBER OF COMMERCE.

Meeting of the Electrical Trades' Section Committee.

A meeting of the Electrical Trades Section of the London Chamber of Commerce was held on Wednesday last at the offices, Botolph House, Eastcheap; Mr. R. E. Crompton in the chair.

The ASSISTANT SECRETARY (Mr. Musgrave) stated that full reports of the last meeting had been given in the technical journals, and these as well as the minutes were taken as read.

Mr. MUSGRAVE then read the following letter which had been received from the Board of Trade:—

"*Electric Lighting Act*, 1888.

"Board of Trade (Railway Department),
"London, S.W., July 16, 1890.

"SIR,—I am directed by the Board of Trade to acknowledge the receipt of your letter of the 23rd ultimo, enclosing a copy of a resolution passed at a recent meeting of the Electrical and Allied Trades Section of the London Chamber of Commerce, on the subject of the regulations to be issued by this Department, under Section 4 of the above-mentioned Act, with respect to overhead wires, and to state that the Board of Trade have carefully considered the resolution adopted by your Chamber, and the arguments in support of it contained in your letter.

"In the preparation of the regulations in question the Board of Trade consulted the Council of the Institution of Electrical Engineers, whose members possess the highest scientific attainments, and have also large practical acquaintance with the working of electric light undertakings.

"The Council devoted a great deal of time and care to the consideration of the subject, and the regulations as now drafted were adopted, with some modifications not affecting the questions raised by your Chamber, on their recommendation.

"The Board of Trade, while anxious to avoid any undue interference with trade, are compelled to have regard to the safety of the public; and they desire me to say that they regret to be unable to modify the model Regulations, as desired by your Chamber.

"I am, however, to add that they will consider carefully, in the case of any particular installation on the series, or other similar system, any application for a modification of Regulation 12, which is supported by the Local Authority of the District.

"I am, Sir,
"Your obedient servant,
"HENRY G. CALCRAFT.

"The Secretary London Chamber of Commerce."

The CHAIRMAN said that probably nothing could be done till November, when it would be possible to re-summon the Committee of the Institution of Electrical Engineers who were alluded to in the letter, and on whom the responsibility was cast. He held that they should not cease to agitate until the rules were made practicable. The use of overhead wires in accordance with these regulations was almost impossible. Major Cardew had stated that reasonable requests for modifications would be considered; but three applications had been made to the Board of Trade, and they had all received a point-blank refusal to consider any suggested modifications. Besides the fact that the conductors made in accordance with the regulations were of ridiculous dimensions, the cost was increased from £28 to £78 per mile. He proposed that that Section of the Chamber should address the Council of the Institution on the subject.

Mr. SWINBURNE pointed out that there were several other equally impracticable rules which had been made by the Board of Trade, such as enclosing transformers in metal cases, and the use of iron tubes for leading-in wires, which were to be of a thickness of a quarter of an inch; this was thicker than gas pipe, and therefore special pipe would have to be used.

It having been pointed out that the rules alluded to by the last speaker had not yet been issued, and that instead of taking particular cases it would be better to urge the inadvisability of framing regulations for a new industry, when even experienced engineers could not foresee the results of proposed rules, which should not be hard and fast,

Major FLOOD PAGE suggested that the Chairman should be requested to draw up a statement of the difficulties which have arisen in consequence of the new regulations, and that the Institution of Electrical Engineers be asked to meet a committee of the Section to discuss the question, since the united action of the two bodies had proved to be satisfactory as to the need for establishing a standardising laboratory.

A resolution was passed to this effect.

The first matter on the agenda was the resignation of the Technical Correspondent. A letter containing the resignation was read, and a vote of thanks was passed to Mr. Trotter, who expressed his regret at being unable to continue to fulfil the duties of the post.

Mr. MUSGRAVE read a communication from the Chemical Trades Section, calling attention to certain evils arising from the improper use of disclaimers in patent law, and asking for the co-operation of those Sections of the Chamber which are interested in inventions.

Mr. SWINBURNE, who had already studied the circular issued by the Chemical Section, gave a very complete account of the difficulty. It arose, he said, from the fact that in the old days of the former patent law, only one specification was required, and it was, therefore, fair that the inventor should be allowed to amend by disclaimer; but the present system of provisional and final specifications did away altogether with the need for disclaimers. He contended that there was no need to amend the system of disclaimers; but now that we have provisional specifications, the need for disclaimers is gone. In no other countries where there are provisional specifications are disclaimers allowed. In the United States, where there is no provisional specification, it is the common practice to draw up the claims of a patent with the view of amending them by disclaimers. The inventor can then wait until after he has made his experiments, and he then disclaims all the methods which he finds to be unsatisfactory. In the United States, a patent for a combination of five separate things is protected by a patent which gives all the possible combinations; first, one of the things in combination with the other four in turn, then combinations in sets of four with the other things, then in sets of three, and so on. The patentee can at a later date wipe out any of these. A patent is a contract between the public and an individual. It was in the first case a monopoly given to anyone who introduced a new process from abroad, then it was extended to cover inventions. It is manifestly unfair that one party to the contract—the public—cannot alter it in any way, while the other—the inventor—is allowed to alter and amend the contract when he wishes. This would never be permitted in any other form of contract.

Mr. MUSGRAVE said that the circular also referred to patents which were taken out and which were not worked.

Mr. SWINBURNE referred to the work of the recent International Convention, and pointed out the different ways in which this affected foreigners. The Austrian patent law demanded that the patent should be worked at least once a year, to maintain its validity. This had given great inconvenience to an engineer who had invented a new way of blowing up iron-clads.

Major FLOOD PAGE said the trade had been very much hampered abroad by the necessity for working foreign patents, and it was impossible to get a definite opinion from the most skilled foreign lawyers as to what constitutes the working of a patent.

Mr. W. W. BEAUMONT said that the matter was a very important one, and thought that the question should be discussed as to whether the system of provisional specifications should be continued, or whether, as an alternative, amendments should be allowed for one year.

After a further discussion, it was decided to co-operate in the matter with the Chemical Trades Section.

Mr. MUSGRAVE stated that the date for receiving applications for space at the Frankfort Exhibition had been extended to September 30th.

A letter was read from the manager of the Edinburgh Exhibition, asking that jurors might be appointed, as suggested by the Section.

Major FLOOD PAGE reminded the meeting that the principal suggestion which the Section had made was to the effect that there should be no awards.

Mr. ALEXANDER SIEMENS said that a similar application had been made to the Institution of Electrical Engineers, and that as no Council meetings are being held, Mr. Webb had called on him to ask what should be done. He thought that it was obvious that members could not be called together at this time of the year, when nearly every one had made his holiday arrangements, and few would care to alter them for the sake of going to Edinburgh at his own expense for this purpose. Mr. Webb had written to ask what the duties were, and had been informed that the jurors would be expected to assist in carrying out experiments to verify statements as to efficiency and output of dynamos, &c. Mr. Webb had written to say that, as far as he could ascertain, it was out of the question that the Council would nominate any of its members for this purpose.

Major FLOOD PAGE remarked that the question should have been raised when the Institution was holding meetings and Council meetings in Edinburgh, when the matter might easily have been arranged.

Mr. ALEXANDER SIEMENS added that Mr. Forrest had received a similar application, and had replied that the Institution of Civil Engineers would be unable to act in the matter.

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After further discussion, it was agreed that a letter should be written explaining why the Section would be unable to give any assistance.

Mr. TROTTER reported that the draft classification of merchandise traffic, under the Railway and Canal Traffic Act of 1888, had been issued by the Board of Trade; and submitted the following analysis, showing the basis and the result of the enquiry which was held before the Board of Trade, so far as the electrical trades are concerned:—

—	Old classification.	Clearing House.	Class in Deposited Schedule.	Class proposed by Chamber of Commerce	Class recommended by Board of Trade.
Dynamos in cases ...	2	3y	Omitted	2	2
Batteries, packed ...	3	3	3	2	3
Sulphuric acid	4	Special	Omitted	C	not dealt with
Telegraph batteries..	3	3	Omitted	3	3
Electric storage batteries	2	2	3	2	2
Cables	4y	4y	4	3	3
Carboys, not glass, empty, not returned..... ...	4	4	Omitted	4	4
Carboys, empty glass	3	4	Omitted	4	5
Cars, tramway	Special	Special	Omitted	Special	carriage class
Castings, iron, malleable	1	1	2	1	1
Castings, iron, steel, light	1	1	2	1	2
Castings, steel	3y	1	3	1	3
Telegraph insulators	1	1	Omitted	1	1
Sheet iron annealed.	1	1	Omitted	1	not packed B
Mouldings	3y	3y	Omitted	2	3
Telegraph posts	1	1	Omitted	1	B
Reflectors, glass.....	4	4	5	4	4
Sponge cloth	2	2	Omitted	2	3
Steel bars, bundles...	2	2	Omitted	2	2
Telegraph cable	4y	4y	Omitted	3	3
Wire, cotton covered	2	2	4	2	2

He observed that the results were on the whole very satisfactory; but he drew the attention of the Chamber to the discrepancy between the concessions of the Companies and the draft classification in the matters of "sheet iron" and "telegraph posts," which are only provided for in 4-ton lots.

The meeting then terminated.

THE HASTINGS AND ST. LEONARD'S ELECTRIC LIGHT COMPANY.

Mr. E. T. Mercer, managing electrician and engineer of the Hastings and St. Leonard's electric supply station, sends us the following particulars of the engines and boilers used by him, together with details of their performance. The underground mains of this Company were described in *The Electrician*, Vol. XXIV., page 186.

The plant is started about half an hour before sunset, and the incandescent lamps are switched off at 12 p.m. About 800 of these are run by contract, this being the total number at this time of the year, most of the shops being closed before light is required. These 800 lamps are contracted to run to midnight. The lamps, of 8 candle-power, 30 volts, are supplied by Edison, Swan, and Co., Ponder's End. The arc lamps are also started at the same time, but are extinguished at 11·15 p.m., and are also supplied by contract. The 38 arc lamps are of the Brush type, known as of 2,000 candle-power nominal, the whole are driven from four Brush No. 8 machines, with separate circuits. The average pressure is about 5,000 volts, the current 10 amperes for arc lamps in one circuit, and 9 amperes for incandescent in three circuits.

The driving power consists of two 40 horse-power nominal engines, and boilers, known as undertype, high-pressure cylinders, 14in. diameter and 22in. stroke, and made by Messrs. Robey and Co., Globe Works, Lincoln. Also one double flue Lancashire boiler, made by Messrs. Duncan, Stewart and Co., London Road Iron Works, Glasgow. The three boilers are connected into one main steam pipe, with a working pressure of 95lbs. per square inch.

The boiler flues are run into a chimney 75ft. high and 3ft. square at the base inside measurements, with natural draught. The fuel burned is gas coke and small coal. About one of small coal to three of coke is used, and this is found to make a first-class fire for generating steam. There is no difficulty in maintaining a constant pressure of steam.

Two boilers are working. The engines are both driving on one intermediate shaft, and running at 80 revolutions per minute. The fires are lighted now at 6 p.m., and the lights are turned on at 7.30, making a run of 4½ hours. Twenty-four cwt. of coke and small coal is burned. The engines are developing 65 indicated horse-power, or 130 indicated horse-power together, for 4½ hours, making a total of 585 indicated horse-power hours, during which time 2,300 gallons of water are evaporated. (The horse-power given above was taken from a diagram each hour with a Richards indicator). This gives 4·6lbs. of coke and small coal per indicated horse-power per hour, and 8·6lbs. of water evaporated per 1lb. of coke and small coal. The price of coke and small coal is 9d. per cwt., so that for 18s. 2,300 gallons of water are evaporated, and produce 585 indicated horse-power hours, to maintain 800 incandescent lamps and 38 arc lamps for one night of 4·5 hours.

The cables are those supplied by the Silvertown Gutta Percha and Telegraph Works Company, and give perfect satisfaction after several years' use.

THE SCHISEOPHONE.

This instrument, as its name so clearly suggests, is intended to act as a "flaw sounder." It is a modification of Prof. Hughes' induction balance, and has been invented by Captain De Place.

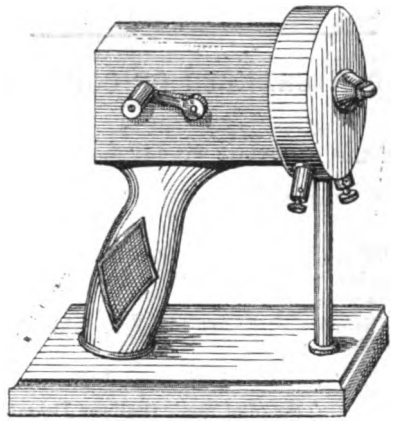

Fig. 1.

Fig. 1 represents an induction coil having a reciprocating core, which can be set in motion by means of a crank, the whole being mounted on a stand with a handle.

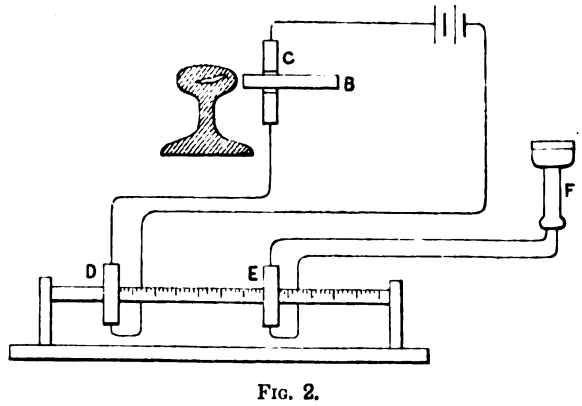

Fig. 2.

Fig. 2 is a diagram of the arrangement. B is the core which moves longitudinally in the coil C. The core is made to strike the object to be tested. A continuous current is sent through the coil C and a coil D, the latter being fixed at one end of an induction balance. A similar coil, E, sliding on a graduated rod, is connected with a telephone. When the core B strikes a sound portion of the metal, a certain quality of click will be heard in the telephone. This noise may be reduced to a minimum, or may be extinguished by adjusting the coil E. When the core B strikes the object to be tested in the neighbourhood of a flaw, the sound in the telephone is increased. The instrument is said by *La Nature* to have given very satisfactory indications of flaws in rails at the depôt of the Chemin de Fer du Nord; in every instance the rail when broken showed a flaw at the place indicated. We think

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that the sensitive state of coil E ought to be produced not merely by its distance from D, but by its relative position between D and another coil. A delicate balance at which the click might be extinguished could then be attained, and an alteration either of decrease or increase of the current in coil D would give a sound in the telephone. We should imagine that though the instrument may be useful in testing a long homogeneous bar, a change will take place near the ends, and it could not be used for testing an object of irregular shape.

TRANSMISSION OF POWER AT DOMENE (ISERE).

A satisfactory example of the transmission of water-power by electricity has lately been started near Grenoble. The water is dammed, with an effective head of 230ft., and is conducted by a sheet steel pipe to the turbine. The generating dynamo is coupled directly to the horizontal shaft of the turbine, and is connected to the two cables of an aerial line, through which the power is transmitted to the motor at Montier, a distance of a little more than three miles. The general conditions of working the plant are, according to *Le Génie Civil*, as follows:—

Generator...	300 h.-p., 240 revs. per min.
Motor	200 ,, 300 ,, ,,
Pressure	2,850 volts.
Current	70 amperes.
Resistance of line.....	3·474 ohms.
,, dynamo fields	0·950 ,,
,, ,, armatures	0·984 ,,
,, motor fields..	0·731.
,, ,, armatures	0·690.
,, total of circuit	6·829.
Electrical efficiency ...	83 per cent.
Mechanical.....	65 ,,

Since this plant was started in the November of 1889, it has not ceased to work day or night, and although the care of the machines presents no difficulty, no increase whatever of the staff has been required. Four men are employed, two at the generator, and two at the motor, each being in attendance for twelve hours. A telephone line is run on the same poles as the working line. Shortly after it was started a frost set in, entirely stopping the traffic, and since that time until March 15th the communication by the roads was cut off. The line was struck several times by lightning, but both generator and motor were fully protected. The power is used for driving a paper mill, and the economy is found to be very marked as compared with the cost of fuel.

ELECTRIC LIGHTING IN ST. PANCRAS.

A special meeting of the St. Pancras Vestry was held on Wednesday evening at the Vestry Hall, Camden Town, under the presidency of Mr. Churchwarden Nathan Robinson, L.C.C., to consider the report of the Electricity Committee, recommending the acceptance of tenders amounting in the aggregate to £50,946. 4s. 3d. for the provision of plant and execution of works necessary to supply the parish with electricity for the purposes of light and motive power of an extent sufficient for 10,000 incandescent lights of 16 candle-power and 40 arc lights.

Mr. ANDREW SWEET, the Chairman of the Committee, who had moved the adoption of the report, said the Vestry by its Provisional Order was empowered to charge 7d. or 8d. per unit. It was allowed to make 7 per cent. profit, and when this was reached the consumers were entitled to a reduction of the cost of the light. In one of the committee's reports it was suggested that the electric light could be supplied at 4½d. per unit. The London County Council had already lent the Vestry £10,000 to acquire the site in Stanhope-street for the purposes of an electric station.

Mr. CLEMENTS said they had no estimate in the latest report of what the profit would possibly be. Including the cost of repaying principal and paying interest on the loan to be secured—the loan being for 30 and not 42 years—and allowing £5,000 for extras, he estimated that the Vestry, if they adopted the report, would commit itself to an expenditure of £71,000. He doubted whether the County Council would be able to advance the Vestry a loan of £50,000 for the purposes of electric lighting.

Mr. CROW proposed, as an amendment, "That the report of the committee be referred back to the committee to prepare and present to the Vestry an estimate of the expected profits, based upon the altered figures of cost now found necessary, and that the further consideration of the report be adjourned until that estimate has been presented." He contended that a private company could supply the electric light better than a public body, and that private individuals could do so better than either.

Mr. VEARS seconded the proposition.

Upon a division after discussion, the amendment was negatived by 47 to 7, and, in the result, the original motion for the adoption of the committee's report was carried, and the necessary tenders were accepted.

The various competing tenders were as follows. It will be seen that the figures differ slightly from those given in our last issue:—

Contract No. 1.—Buildings.

Holliday and Greenwood, Loughborough Works, Brixton	£5,532	0	0
Mowlem and Co., Westminster	5,237	0	0
Pattinson, 5, Whitehall, S.W., and Rushington, Sleaford	5,130	0	0
Kirk and Randall, Woolwich (accepted)	4,629	0	0

Contract No. 2.—Boilers.

Fraser, Cannon-street, E.C...	£4,592	0	0
Crompton and Co., Chelmsford	4,049	0	0
Electrical Engineering Corporation	3,835	0	0
Taunton, Delmard, Lane and Co., Birmingham ...	3,772	0	0
Babcock and Wilcox Company, Newgate-street, E.C. (accepted)	3,674	10	6
Sharp and Kent	3,674	0	0

Contract No. 3.—Engines, Dynamos, &c.

Siemens Bros. and Co. (Tender No. 2)	£27,349	0	0
Brush Electrical Engineering Co.	20,078	0	0
Siemens Bros. and Co. (Tender No. 1)	20,004	0	0
India-Rubber, Gutta Percha, and Telegraph Works Company	19,661	0	0
Crompton and Co.	19,393	0	0
Willans and Robinson (Tender No. 1)	19,014	0	0
Johnson and Phillips	18,980	0	0
Sharp and Kent	18,974	0	0
Electrical Engineering Corporation	18,865	0	0
Laing, Wharton and Down (Tender No. 1)	18,356	0	0
Willans and Robinson (Tender No. 2) ...(accepted)	18,202	0	0
Nicholson and Jennings	17,900	0	0
Gulcher Electric Light and Power Company	16,929	0	0
Laing, Wharton and Down (Tender No. 2)	16,491	0	0

Contract No. 4.—Switch-boards.

Siemens, Bros. and Co.....	£2,562	0	0
Laing, Wharton, and Down.....	1,604	0	0
Electric Construction Corporation (accepted).....	1,314	0	0
Sharp and Kent	1,150	0	0
Appleton, Burbey, and Williamson	1,061	0	0

Contract No. 5.—Batteries.

Crompton and Co.	£3,110	0	0
Latimer Clark, Muirhead and Co.....	3,047	0	0
Electric Construction Corporation (accepted)	2,745	0	0
Sharp and Kent	2,737	0	0
Johnson and Phillips	2,342	0	0

Contract No. 6.—Trenches for Mains.

Latimer Clark, Muirhead, and Co.....	£17,808	0	0
Sharp and Kent	12,191	0	0
Mowlem and Co. (accepted)	10,726	0	0

Contract No. 7.—Conductors for Mains.

Sharp and Kent	£14,740	0	0
Reid Bros.	14,115	0	0
Latimer Clark, Muirhead, and Co. (accepted)	13,625	0	0

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *July* 25, 1890.

Prof. Elihu Thomson's New Motor.—Professor Elihu Thomson has just patented a form of dynamo that is almost as remarkable in its way as the Duncan motor. It is peculiar in that there is no external field, and hysteresis is reduced to a very low figure. The field coils are only two in number and embrace a massive cylinder, having around its centre a star-shaped mass that constitutes a group of six consequent poles. The magnetising coils are wound on iron bobbins that support the bearings on which the internal cylinder revolves. The whole cylinder of iron connects the base-plates of these bobbins and shuts in the whole machine. Within the central portion of the cylinder is a belt of poles pointing regularly inwards and just clearing the revolving poles. Around these outer poles are wound the coils of the armature, which is, of course, stationary. The revolving poles are all of one polarity and the stationary ones all of the other, so that when the former are set in motion a rapidly alternating current is induced in the armature. It will be seen that there are no sliding contacts of any sort in this machine, while the hysteresis is necessarily small.

Lighting of New York Streets.—The difficulty between the Gas Commission and the electric light companies still continues.

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The bids last May for street lighting were practically at the old rates until January 1st, when a newer and higher rate will come into effect. The Gas Commission has accepted the bids up to January 1st, thus leaving the question of an increased price later still open. Mayor Grant protested through the proceedings as usual, and put himself on record as in favour of lighting with gas rather than coming to any sort of terms with the electric companies. One of the latter declares in the most outspoken manner that, at the old prices, there was no profit in city lighting, and challenges inspection of its books in proof of this assertion.

Westinghouse Traction Work.—The Westinghouse Electric Railway Company is pushing vigorously, and has already taken a number of contracts for the equipment of electric roads. A few of their new cars have recently been in operation in Pittsburgh, Pa., and have given excellent satisfaction. The new Westinghouse system is very closely similar to the Sprague and Thomson-Houston systems now in such extensive use, although differing in some mechanical details. The machinery is said to be very well made and to promise high efficiency, but there is nothing specially novel about it. The Westinghouse Company is also preparing to put on the market a new alternating motor, the details of which have not as yet been made public.

Another Motor for Alternating Currents. — Still another alternating motor is about to make an appearance, invented by Mr. Slattery, electrician of the Fort Wayne Electric Company. The new machine is said to be self-starting, even under full load, and to have a large output in proportion to its weight.

The Consolidation.—Nothing has come, so far, of the much-talked-of plan of consolidating the Thomson-Houston and Edison Companies. There is some hitch in the arrangement, but any form of arrangement between the parties immediately concerned seems to be deferred. Both companies are doing a very large amount of business, the Edison Company in its new and efficient organisation having made specially rapid progress of late.

The Fire at the Western Union Telegraph Office.—The fire in the Western Union building recently proved to have caused far smaller damage than was at first probable. The actual injury done will probably be repaired for less than a quarter of a million dollars. The company displayed great activity in carrying out repairs, and is now able to handle nearly its normal volume of business, although its forces are still somewhat scattered. Large additions are contemplated to the building when it is reconstructed, and more care will probably be taken in rendering it fireproof and in insulating and distributing the wires so as to prevent the possibility of a similar accident again.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *Aug.* 5, 1890.

The lighting of the boulevards and quays of the Canal St. Marstin by arc lamps is daily increasing. Paris will soon be surrounded by a circle of lighting. There have been some experiments in lighting the streets by glow lamps; amongst others the Rue des Halles by Khotinsky lamps, in groups of two or five in the gas lanterns, the current being supplied by the municipal station at the Halles. The Rue Auber has also been lighted by Edison-Swan lamps, singly or in threes, in the gas lanterns, with small white reflectors. Where 16 candle-power lamps are used, the light is much better than that of gas. These lamps are run from the station at La Place Clichy. On the Boulevard Montmartre, near the corner of the Faubourg Montmartre, the large café "La Splendide Taverne," is lit with 550 16-candle lamps, 8 Pilsen arcs of 10 amperes, and 2 arcs of 8 amperes. The compound engine by Dufaut and Robatel, of Lyons, is placed in the cellars; it runs at 78 revolutions per minute, and drives a Fabius Hanrion dynamo for 350 amperes at 110 volts, at 550 revolutions per minute. Collet boilers supply steam at 114lb. per square inch.

The Popp Company is about to change the whole system of distribution which it established last year; this system consisted of cast pipes, with joints made with india-rubber. The system which they are now adopting consists of a cast-iron box of rectangular section in which they place five double casings, resting on paraffined wood. The box is closed with a cast-iron lid. Before each house a branch box is established. The connections between the cables of the customers and the mains, are made with screw couplings, without soldering. In the high-pressure service for charging the accumulators, the cables are coloured red, while those for distribution at low-pressure are black.

AUSTRALIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

SYDNEY, *June* 29, 1890.

ELECTRIC TRAMWAYS.—The work in connection with the trial of an electric tramway on the Thomson-Houston system is progressing rapidly, and it is expected that in about two months from date the first cars will be running. The experiment is causing considerable interest in Sydney, a change from the present steam system being considered desirable. Should this experiment be as successful as the promoters anticipate, and should it meet with the approval of the local authorities, there is little doubt that a large business will be the ultimate result. Another electric tramway project is being pushed by the Crompton Electric Company, this time on the accumulator principle. The scheme is, however, at present only in its first stage, and some time must necessarily pass before its completion.

LIGHTING OF TRAINS.—The New South Wales Railway Commissioners have been taking steps to improve the lighting of the trains on their lines, and to this end they have just completed a most successful experiment with the electric light. The system adopted was the accumulator system. The train on which the experiment was made was the express to Albury, and a sufficient charge was stored to last for the return trip. The whole affair appears to have been a success, and it is expected that the Commissioners will now take steps to introduce the new illuminant into more of their trains. The accumulators used were those of the Crompton Electric Company, while the lamps were the Thomson-Houston.

GROSS'S ELECTRIC COMPASS.—This invention, of which Mr. Gross is the inventor, was put to a thoroughly practical test last week on board the s.s. "Bulimba," the compass of which vessel was replaced by one of the new design. The object of this invention is to indicate by an electric bell placed in the captain's cabin any deviation from the course laid down, through the carelessness or neglect of the man at the wheel. From a conversation held with those on board the "Bulimba" it would certainly appear to have had a good effect on the sailors, the steering having been very much better than usual on this trip. Those connected with the invention appear to have confidence in the success of their enterprise, and if, as it would seem, it is going to lessen the dangers to life and property at sea, it is to be hoped that shipowners will take it up.

CORRESPONDENCE.

PROVING OHM'S LAW.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is not quite clear from Prof. Oliver Lodge's letter (p. 359) in what way he wishes Ohm's law to be taught—or proved. He first says that it is, when stating Ohm's law in the usual symbolic way, ridiculous to begin by defining resistance as a ratio. And then he goes on to state Ohm's law as a ratio, and calls that ratio "resistance." Where is the difference? To be sure, he qualifies it by saying that such ratio, called resistance, is not a function of the current intensity; but that brings us no "forrader," because he has already cut away the need for such qualification by adding previously the proviso that the conductor must be "in a given state." If it is "in a given state," then either the current intensity through it has an effect on its state, or else it has not. If the current intensity has no effect on its state then the proviso about resistance not being a function of current intensity is superfluous. If, on the other hand, the current intensity has an effect (as we know it has, in fact, in iron and in bismuth) on its state, then it is an absurdity to say that the resistance of the conductor *in a given state* is not a function of current intensity. Will Professor Lodge kindly reconsider the phraseology of p. 359, which, partly by no fault of his, is "in a given state" of admirable derangement, a function of other variables than his own usually lucid current of ideas?—Yours, &c.,

SILVANUS P. THOMPSON.

[We regret that the proof of Dr. Lodge's letter, which was posted on Tuesday, 26th, was not delivered to him until

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Friday morning, and allowed him no opportunity of making a correction. For "rates" read "ratio." The author meant, "Ohm's law is obeyed when simple proportionality holds between current and E.M.F. in a given conductor."—ED. *E.*]

EDISON AND SWAN UNITED COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest your criticism on the Edison and Swan Company's accounts for the year ended 30th June last, but I am sorry to see you have not touched upon what I consider to be the only unsatisfactory feature about them, and one which I think will be found very difficult to explain. It is this—the cost of producing the lamps sold for £118,865 was £73,719, as against £62,529 for making £111,715 worth in the previous year. We have thus an increase in the sales of £7,150, and of expenses in manufacturing the articles sold £11,190. At first I thought this could be accounted for by the very large increase in the stock, but when at the meeting Mr. Forbes explained that this particular increase was almost entirely due to the purchase of a large quantity of platinum, I cast about for some other explanation, and, so far, I have been unable to find it. There has certainly been no reduction in the net selling price of the lamp; in fact, I fancy, if anything there has been a slight increase.

Now, if lamps, and good lamps, too, can be made and sold on the Continent at 1s. 3d. each, how is it that the same thing here costs somewhere about 2s. to be manufactured, without reckoning one farthing for general expenses (*i.e.*, Directors' fees, rent, &c.) or depreciation of plant? Even in America where labour is so dear, incandescent lamps are *sold* at about 2s. each, and doubtless at a profit:

How you arrive at the amount of the Directors' and Auditors' fees paid by the Edison and Swan Company is a puzzle to me. Perhaps you will not mind letting me know what these figures are, and, at the same time, be good enough to tell me how you calculate the proportion of net to gross profit, which you say is 51½ per cent.?

Finally, I make the amount carried to reserve (£8,093) equal to more than 13 per cent. of the profit of the net balance in the profit and loss account.—Yours, &c., A SHAREHOLDER.

August 2, 1890.

[We are obliged to our correspondent for pointing out a slip, by which we gave the Directors' fees of Crompton and Co. as those of the Edison and Swan United This does not affect our point, viz., that they are not excessive. The balance, £61,115, was taken as the net profit, and compared with £118,865. The reserve fund was that on the balance-sheet, not on the proposed appropriation of profits. We do not care to follow our correspondent in his criticisms, as it is not our custom to enter into financial controversies nor (except in serious cases) to dwell on "unsatisfactory features." Our object was rather congratulation on the details.—ED. *E.*]

THE PRICE OF ELECTRICITY AT BATH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I, together, no doubt, with many of your readers, was amazed to hear that at Bath Mr. Massingham proposed to charge 6s. only per 10 candle-power lamp for current supplied; but, considering that Mr. Massingham had had some experience of central station lighting, I withheld from expressing an opinion in the matter until some explanation was forthcoming, or some of your "knowing" correspondents had expressed *their* opinion of the venture.

I therefore turned to your issue of to-day with more than usual interest, and although I cannot go so far as to say with your correspondent that 1,800 hours per annum is a fair estimate of the time that lights are used, I can, from personal experience, say that 700 to 800 hours is not too much to calculate when the general lighting of a town is gone in for, including hotels, bars, ordinary shops, underground cafés, &c.

In the case of a Company with which I am connected, and where we have about 6,000 10 candle-power lights going, the average hours of lighting is 770 hours per annum, which would mean about 2¾d. per unit if charged at Mr. Massingham's rate.

I venture to say therefore that the price of 6s. per annum is a ruinous one, but if the Bath installation can be made to pay, or to pay itself, at this price, then the electric lighting star will indeed be in the ascendant and the career of gas companies for illuminating purposes will be short, especially in the south, for the Bath rate of charge must be equal to very little more than 2s. per 1,000 feet for gas.

While, therefore, doubting the success of the scheme, I wish it every success, and shall watch its progress with interest. I enclose my card, and remain, yours, &c.,

August 1, 1890. NORTHERN.

TRADE NOTES AND NOTICES.

SOFIA.—The Agent and Consul-General states that any British firms desirous of tendering for the lighting of this town by electricity should lose no time in communicating with M. D. A. Zenow, of Sofia, or with the Mayor, M. D. Pethoff.

DISSOLUTIONS OF PARTNERSHIP.—The following firms have dissolved partnership:—George Weston and William Prince, electricians, Dashwood House, New Broad-street, London, E.C.; and Louis John Crossley, Walter Emmott, and John Frederick Harrison, electricians, Bradford.

TENDERS WANTED.—The Helston Town Council invite tenders for lighting the public streets and buildings in Helston by gas, oil, or electric light. Full particulars may be obtained from Mr. J. G. Plomer, Town Clerk, to whom tenders are to be sent by the 16th inst.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

July 8, 1890.

10,527. E. S. D'ODIARDI and A. THOMPSON. London. Improvements in magneto-voltaic and static electrodes.

10,528. E. S. D'ODIARDI and A. THOMPSON. London. Improvements in electric atomizers.

10,530. E. S. D'ODIARDI and A. THOMPSON. London. Improvements in liquid electrodes.

10,531. E. S. D'ODIARDI and A. THOMPSON. London. Improvements in electro-inhalers.

10,538. G. J. WIER. Hillcrest, Patrick Hill, Glasgow. Improvements in galvanic batteries.

10,549. G. H. HART. Harborne, near Birmingham. An apparatus for signalling by means of electricity combined with a field-glass, telescope, or other instrument containing lenses.

10,577. P. JENSEN. London. Improvements in automatic electric fire alarm systems. (The European Fire Service and Motor Company, United States.)

10,587. P. KNOCH and M. PFEIFFER. London. Improvements in electric switch apparatus.

10,593. S. C. C. CURRIE. London. Improvements in electric motor apparatus.

10,595. E. THOMSON. London. Improvements in apparatus for measuring electrical energy.

July 9, 1890.

10,640. W. W. WILLMOTH. London. Improvements in sash fastenings and sash latch locks, and electric bell contact alarm, burglary preventor and detector.

10,646. M. H. KILLGOUR. London. Improvements in apparatus for automatically controlling or maintaining electric circuits.

July 10, 1890.

10,712. A. E. NICHOLS. Westminster. Improvements in electric lamp couplers or holders.

10,714. W. LUCAS and T. A. GARRETT. London. Improvements in and connected with electrical apparatus for recording the presence of watchmen, workmen, or others.

10,736. M. P. OUDIN and H. O. KRATZ BOUSSAC. London. Improvements in electric lamps for medical and surgical purposes.

10,740. SIEMENS BROS. and Co., LIMITED. London. Improvements in incandescence bodies for electric glow lamps (Siemens and Halske, Germany).

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10,741. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in incandesence bodies for electric glow lamps (Siemens and Halske, Germany).

10,742. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in incandescence bodies for electric glow lamps.

10,743. SIEMENS BROS. AND CO. (LIMITED). London. Improvements in the means for effecting conducting connection between overhead conductors on electrical railways and tramways and the electrical apparatus on the vehicles.

July 11, 1890.

10,765. A. W. HEAVISIDE and R. C. JACKSON. Whitby. Improvements in means or devices for detecting electrical inductive effects.

10,768. J. M. M. MUNROE. Glasgow. Improvements in shades for electric lamps for displaying goods in shop windows and other places.

10,792. F. WILCOCKS. London. A new or improved combined door-knocker and electric bell.

10,801. J. J. GILBERT London. Automatic clock-work apparatus for effecting cooking operations, the lighting of fires and the like, also applicable for giving electric signals.

10,805. B. J. B. MILLS. London. Improvements in methods and apparatus for applying the power of electric motors, especially applicable to electric railways (T. A. Edison, United States).

10,806. B. J. B MILLS. London. Improved underground conduit system for electrical distribution (E. T. Greenfield, United States).

July 12, 1890.

10,857. J. M. M. MUNRO. Glasgow. Improvements in metallic coverings for electric wires (Dated July 11).

10,868. E. DE PASS. London. Improvements in electricity meters (Etienne Marès, France).

10,900. C. VANDERBILT. London. An improved electric switch alarm.

July 14, 1890.

10,939. C. MCDONALD. Clapham Junction. Electric lamp holder and switch for capped incandescent lamps.

10,941. F. WYNNE. London. Improvements in electrical contacts or collectors of electricity for railway and other purposes.

July 15, 1890.

10,981. J. S. WARBURTON. Grays, Essex. An improved "cut-out" for "arc" lamps.

11,017. W. P. THOMPSON. Liverpool. Improvements in or relating to conduits and permanent way for electric railways (J. Lynch, United States).

11,025. J. Y. JOHNSON. London. Improvements in connection with dynamo-electric generators regulating the circuit currents to arc lamps (Higham Patent Right Company, United States).

11,041. J. D. F. ANDREWS. London. Improvements in armoured electric conductors, and in jointings for such conductors.

11,042. J. W. GOOCH, C. A. BAKER, and W. WHITE. London. Improvements in electric thermometers and thermographs.

11,061. H. H. LAKE. London. Improvements in electric railway switches (W. D. Swart, United States).

11,065. G. A. ONCKEN. London. Improvements relating to the impregnation of organic, fibrous, and cellular matter, by means of an electric current, and apparatus therefor.

July 16, 1890.

11,070. J. SWINBURNE. Teddington. Improvements in and connected with electric measuring instruments, incandescent lamps, telephone transformers, electrically worked organs, and materials for jellygraph copying and printers' rollers.

July 17, 1890.

11,130. A. N. FORD. London. Improvements in insulating compositions for electrical purposes.

11,187. A. W. ARMSTRONG. London. Improvements relating to the manufacture of articles by electro-deposition, and to compositions for use in such manufacture.

11,193. J. TRECZIOK. London. Improvements in electrical switches.

July 18, 1890.

11,240. J. Y. JOHNSON. London. Improvements in electric arc lamps (Louis Bardon, France).

11,263. J. M. M. MUNRO. Glasgow. Improvements in wall-sockets for temporary electric connections.

11,272. T. R. ANDREWS and T. PREECE. Bradford. An improved ceiling rose for the suspension of electrical fittings.

11,319. H. HOWARD. London. Improvements in apparatus to be used for electric welding.

11,327. C. T. J. VAUTIN. London. Improved electrically operated stamping and crushing machines.

SPECIFICATIONS PUBLISHED.

1889.

11,332. HEDGES. Dynamo-electro machines. (Price 8d.)

11,519. FARQUHAR and DOULTON. Electric lamps. (Price 6d.)

11,997. EMMOTT and ACKROYD. Electric meters. (Price 6d.)

13,001. DE POULPIQUET. Electric fire-alarms. (Price 8d.)

13,282. SLATTER. Electric lamps. (Price 8d.)

14,086. JOHNSON and PHILLIPS. Electrical transformers, &c. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors in the Anglo-American Telegraph Company (Limited) was held at Winchester House, 50, Old Broad-street, on the 1st inst., under the presidency of the Marquis of Tweeddale.

The SECRETARY (Mr. T. H. Wells) read the notice calling the meeting and the minutes of the last meeting.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said: I have to apologise for the absence of our respected Chairman, who, I regret to say, is suffering from severe indisposition, and is, therefore, unable to attend to-day. You will have noticed from the report that the traffic receipts show an increase of £2,025 over those of the corresponding period of last year. This increase is satisfactory, first, because the half-year under review is the less profitable of the two, and, in the second place, because it is mainly due to the establishment of three new offices in the City of New York. This has brought us more in contact with the telegraphing public of that important city, and the benefit of these offices will no doubt be still further realised when they are better known than they are at present. There is one very satisfactory feature in our report, and that is that the whole of our cables are in good condition. We have had fewer faults to repair than usual, in a great measure owing to the alteration made in the position of the Duxbury cable, which was referred to on two previous occasions, and which has realised our expectations. But not only are our own cables in good working order, but all the cables in the "pool" are in equally good condition. We have learned that one of the cables of the Western Union Company, which has been out of order for some time, has been repaired at a depth of something like 2,500 fathoms. Our traffic has been conducted during the past half-year with the usual accuracy and efficiency, and, I am glad to add, at a speed higher, I believe, than that of any other company doing business in the Atlantic. I am sorry I cannot report the settlement of the dispute with the Paris and New York Company. We have been expecting to hear of it, I may say, for the past six months; but I have no information that I can give you as to when the decision may be anticipated. Turning to the revenue account, you will observe that the working expenses, when compared with the corresponding period of last year, show an increase of £5,692. This is almost entirely made up of one item, namely, £4,352, which was spent on the establishment and working of the three offices in New York, to which I have referred. The balance is made up of a number of small items, calling for no particular comment. There is another item in the accounts which, I think, demands explanation, and that is repairs of cables which show an excess in expenditure of £2,023. This is really a satisfactory feature, inasmuch as the repairs have been entirely of a character to be charged to revenue. Under the head of renewals the expenditure has been extremely small, being only £552, and consequently nearly the whole of the interest accruing on the investments forming our renewal fund has increased that fund to £968,861, the market value of which is about £50,000 more. The renewal fund, therefore, amounts to rather over a million. You will have noticed, I dare say with satisfaction, that the ship "Minia" earned £4,840. It had been lent to the Direct United States Cable Company to repair their cable. There is only one other item in the report which demands any notice—that is, the acquisition by this Company of the Brest-Salcombe cable. The details are set forth in the report, and I have only to add that the terms on which the acquisition has been made are altogether satisfactory. I do not think I have anything to add to what I have said, but I shall be very happy to answer any questions that may be addressed to the Chair. I now propose:—

"*That the report of the Directors and the accompanying statement of accounts to the 30th June, 1890, submitted to this meeting be, and the same are hereby, received and adopted.*"

Sir JAMES ANDERSON seconded the motion.

Mr. W. GRIFFITH thought that the information given in the report with regard to the acquisition by the Company of the Brest-Salcombe cable was rather scant, and he would be glad to be informed of the amount they were to receive every year out of the joint purse receipts for working and maintaining the cable.

The CHAIRMAN said the information could be easily obtained at the office, and it was a very small matter.

Mr. GARLAND regretted that the whole of the interest had been credited to the renewal fund. He thought there had been scarcely a meeting at which this proceeding had not been objected to by the majority of the shareholders; and he considered that they to ought come to some understanding as to what the amount of the renewal fund was to be. This money could not belong to anybody else but the shareholders, who, he thought, ought to have a voice in the matter; whereas, it seemed to him, they had very little voice respecting it. The Directors had, at the different meetings, said that they would consider it; but it had never been considered sufficiently to use any of it for dividend purposes. He, for one, decidedly objected to the renewal fund being increased to an unlimited amount. There ought to be a stated sum, and if it were trenched upon, it then ought to be increased again to that limit, but it ought not to go beyond.

Mr. GRIFFITH said he thought it was agreed sometime since that the renewal fund should not exceed a million. A committee was formed, and there were considerable discussions on the matter, and this was the tacit understanding which was arrived at between the Board and the Committee. Nominally the fund did not yet exceed a million; but as the value of it was about a million, he thought they were entitled to recall to the Directors the tacit agreement come to in the past. If the value of the

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securities exceeded a million, he thought the amount had been reached beyond which it was tacitly understood that this fund should not go. They were very willing to accept the report, but he trusted that the Directors would abstain on the next occasion from putting the interest to the renewal fund if the value of the securities was maintained, in which case the interest might be divided among the shareholders. This would be carrying out an implied agreement, and he thought it would make the Board more popular with the shareholders than they were at present.

Mr. HUMPHRIES suggested that the interest on the renewal fund, which had come entirely out of the pockets of the Deferred shareholders, should now be given to that section of the proprietors. It would produce something like 1 per cent. for them, though that would be a very small return for an investment so peculiarly secured as theirs was in this Company. Still, it would be a comfort to those who had hitherto not received anything. He hoped the Deferred shareholders would assent to his proposition that from this time forward the whole of the interest on the renewal fund should be appropriated to the Deferred shareholders, from whose pockets the money now forming the renewal fund had been kept.

Mr. ROBERTS, referring to the first paragraph in the Directors' report, said that the balance was estimated at £152,000, "subject to revision, as the lawsuit between this Company and the Paris and New York Company is still pending." This matter was still pending, and what he wished to know was whether the Paris and New York Company had any claim on this £152,000.

The CHAIRMAN: No. With respect to the renewal fund, let me remind you of the agreement come to in this room some two years ago, by which the Directors agreed that they would stop further contributions from revenue to the renewal fund when that fund amounted to a million, after which the interest of the fund alone would be added to the principal. That was the agreement come to, and I do not think there is any reason to believe that the shareholders, in this room or out of it, would desire so see a change in that respect. It is of the utmost importance in their interests that we should have a very ample fund of that kind; for, let me remind you, our cables are not any younger, but are growing older every day, and we may possibly soon find ourselves obliged to spend a considerable sum on renewals. I am, therefore, afraid that on that head I am not able to hold out any hope of any change being recommended by the Board in dealing with the question of the renewal fund. He then put the resolution in the usual way, and it was carried unanimously.

Mr. GRIFFITH thought that the shareholders ought not to separate without tendering a vote of thanks to the Board of Directors. These gentlemen might not agree with them in all points of policy, but they were showing a friendly spirit towards them, and in the future they might agree with them still more. He thought that the shareholders had to thank the Board for what they had done, and he hoped they would do more for them when the opportunity offered.

Mr. JACKSON seconded the motion, which was carried unanimously.

The CHAIRMAN: I beg to thank you on behalf of myself and my colleagues for this kind expression of your confidence.

The proceedings then terminated.

The Cuba Submarine Telegraph Company (Limited).

The thirty-eighth ordinary general meeting of this Company was held at the offices, 58, Old Broad-street, on Wednesday, August 6th, under the presidency of Mr. Thomas Greenwood.

The SECRETARY (Mr. James Scott) read the notice convening the meeting; and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen,—The Directors are pleased to meet you again to discuss our affairs in which we are mutually interested, and to give you any further information that you may desire beyond that which is given in a concrete form in the report and accounts. The half-year has been a time of some little anxiety to the Board, but I think you will agree with us that it has been a by no means unsatisfactory half-year. You will remember that the half-year ended June last was the second half of the first year of the reduced rates, and, therefore, in making a comparison of the revenue you must please take into account the fact that it is compared with a period when the rates were 25 per cent. more than they have been during the period under review. Still, the receipts have kept up wonderfully well. You will have observed that they were £23,671 in June, 1889, and £23,206 in June, 1890, or a difference of only £465 between the two periods. Of course, a larger number of messages has been carried under the reduced rates, otherwise we should not have had such a large income; and notwithstanding that it usually occurs that when there is a larger number of messages there is also a larger amount of working expenses, it has not been so with us. Comparing the two half-years ended June, 1889, and June, 1890, there has been a reduction of expenses of £30, making the net difference on working only £435—that is to say, taking the income on the one side and working expenses on the other. It may be asked if the difference is so small, how comes it about that your dividend is reduced from 9 to 8 per cent.? The answer to that is very simple, namely, that we have now increased the divisible balance carried to the next half-year, while to pay the 9 per cent. dividend twelve months since the corresponding balance was considerably lessened. In the future, we shall compare what will be fairly comparable, that is to say, the income of 1890-1, as against that of 1889-90, both at the reduced rates. I am pleased to tell you that the traffic for the last month has increased by £150, as compared with the same month of the previous year; and if that rate should continue we shall have something like £900 at the end of the half-year, a sum sufficient to make up a dividend of 1 per cent. So that I think we may look forward to the future with satisfaction. There is, apparently, no reason to suppose that the dividend is likely to be reduced, provided we are not interfered with by outside influences. I use these words advisedly, because you are aware that a proposition is before the Spanish Government for making another line on the north coast, which, if made, would take away a large portion of the traffic we carry now. At the same time the Spanish Government have brought under our notice the rates which we are charging, with a view to ask us to reduce them still further. That representation is not made to us alone, but to all the telegraph companies which have their location in the Spanish Colonies. Having already made so large an abatement, it seems unfair to ask us for a large reduction now, more especially when the Government are consenting to the extension of another company's line almost parallel to our own. We are not disposed to make any abatement in our charges so long as that extension threatens us, nor unless other companies reduce their charges in the same way. We have made a smaller addition to our reserve fund than in the corresponding period of last year, for the reason that we had to lay out so much on our cables. We have it either in meal or malt. The expenditure has been unusual this half-year for repairs, because we not only had to repair the Batabano—Cienfuegos cable three times—which was broken twice by ships' anchors—but also to repair the 1875 cable between Santiago and Cienfuegos. It has been thoroughly repaired, so that we have a complete duplicate system between the latter two points; and when the new cable which is about to be laid down is finished, our cable system will be duplicated from one end to the other. I am pleased to say that considerable progress has been made in the manufacture of the cable. Already 60 knots of core are insulated, of which 50 knots have been passed by our engineers, and out of that number 18½ deep-sea and 4½ intermediate have been finished, and we may reasonably expect that this new line will be laid from end to end in a few months. I think I have given you all the information that we have at our disposal, and I will now move:—

"*That the report and accounts for the half-year ended 30th June last now submitted be received and adopted.*"

Mr. ALEXANDER F. LOW seconded the motion.

Mr. COCHRAN thought that it would be interesting to the shareholders to know how it was proposed to pay for the new cable which had been contracted for. There had been a somewhat heavy increase in their London expenses in the matter of salaries. The difference, it was true, was not very serious, but if the item were to assume a progressive character, and their business was to be interfered with by other regulations, he thought it was important that the Directors should take care that the expenditure should not grow unduly.

Mr. KING asked whether the French Company had made any progress with its threatened competing line on the north coast of Cuba.

The CHAIRMAN: No progress has apparently been made by the French Company. It is necessary that the Government should place in the possession of the Court certain papers before any progress can be made, and those papers have not been lodged. The whole thing has been in abeyance during the past six months, and I need scarcely tell you that no progress is good news for us. In answer to Mr. Cochran's question, I may say that the cable referred to is to be paid for in cash by four instalments of 25 per cent. It is not to be paid for in the shape of a rental. As we had the money in our pockets I am pleased to say that we were able to make fairly good terms. Regarding the salaries, I think I may say that we have arrived at the maximum. They are not likely to go beyond their present figure. There has been a small increase, but the Board considered it only fair to take into consideration the past services of the staff and the number of years they had been in the employment of the Company. The travelling expenses were incurred by the fact that it was necessary for the Secretary to go to Madrid—where he rendered very useful service to us—to oppose the application of the French Company.

Mr. COCHRAN: It is not an action at law, is it?

The CHAIRMAN: Yes, it is. The circumstances are these. The proprietors should know that the Spanish Government has made a royal order, which is practically an informal admission that it is desirable that an opposition cable should be laid; and that being so we brought an action, having previously made representations to them again and again on the subject before the order was passed. But having been passed we thought it best to bring an action against the Government to test whether they had a right to allow another cable to be laid to compete with our own.

The motion was agreed to unanimously.

The CHAIRMAN then moved:—

"*That the following dividends for the half-year be now declared upon the shares of the Company, viz., at the rate of 10 per cent. per annum, subject to income tax, on the Preference shares, and 8 per cent. per annum, free of income-tax, on the ordinary shares, payable on and after to-morrow.*"

Mr. NEIL BANNATYNE seconded the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. BANNATYNE, the retiring Director, Mr. A. F. Low, was re-elected to his seat at the Board.

Mr. John Gane, the auditor, was also reappointed, on the motion of Mr. C. W. PARISH, seconded by Mr. COCHRAN.

Mr. COCHRAN then proposed, and Mr. KING seconded, a vote of thanks to the Chairman and Directors, which was carried unanimously.

The CHAIRMAN, in reply, said that the small attendance of the shareholders was a fair indication that they had nothing to complain of in the conduct of the Board, who, he could promise them, would always do their best to protect the interests of the shareholders.

The proceedings then terminated.

The Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of the shareholders of the Maxim-Weston Electric Company (Limited) was held at Winchester House, Old Broad-street, E.C., on Thursday, for the purpose of considering, and, if deemed expedient, of passing the following resolution, viz.:—

"*That it has been proved to the satisfaction of this meeting that the*

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Company cannot by reason of its liabilities continue its business, and that it is advisable to wind up the same, and accordingly that the Company be wound up voluntarily."

Mr. J. B. Gooding (Chairman of the Company) presided.

The CHAIRMAN, in moving the adoption of the resolution, said he was sorry to have again to meet the shareholders of the Company under unpleasant conditions. The Board, however, were in no way responsible for the disastrous position in which the Company was now placed. The Company had apparently been started under very unfavourable conditions, having a nominal capital of £40,000 or £50,000, on which only £14,000 was subscribed. The shareholders had already been made acquainted with the manner in which the money had been spent, and the Board now found themselves practically without resources. The shareholders were aware that one meeting had aleady been held for the purpose of ascertaining their feelings on the question, whether any further capital should be subscribed with a view to continuing the Company's business. Although £1,500 had been promised in the shape of debentures, that sum had not been sufficient to admit of the Directors going on with the concern; and accordingly the shareholders were now asked to consider the proposed resolution to voluntarily wind up the business. Before he submitted the resolution, he desired to place before the shareholders a number of figures concerning the Company's business in the past six months. On January 1st there was, roughly speaking, £5,000 in hand. On account of shareholders £30 had been received, and transfer fees to the amount of £5. Bank interest had amounted to £13 10s., and there were also other sums—for loan, £50; accounts collected and work done, £1,200; total, £1,303 4s. 5d., giving a gross amount of £5,700. The Board had paid on Directors' fees, £148; on salaries, £467; on wages, £336; on rates, taxes, and rent, £220; on gas account, £106; on travelling expenses, £28. 4s. 4d.; on petty cash, £125; on trading account, £2,255; on liquidation costs, and other expenses incidental to legal matters, £970; making a total of £4,658, and leaving a balance of £1,031, of which £1,000 lay at bank to the credit of the liquidators of the old Company. The Company's present liabilities amounted to £256. Cash in hand and amount to be collected amounted to £74. At St. Margaret Mansions the Company had an asset—whether it would be recoverable was a matter to be decided hereafter—of £300; so that although the Board came before the shareholders with a very bad state of affairs, the Company would go to the wall without taking anyone with it; in fact, it would pay all its liabilities. The Company, however, could not continue business. The Board have received one or two very encouraging letters from shareholders; but the result of the previous meeting had not been satisfactory, and the Directors, therefore, came forward with the present resolution.

A SHAREHOLDER: How do we stand in our lawsuit?

The CHAIRMAN: The action with Mr. Watt is still pending, but our solicitor states that it is likely to be completed in the present year, after the vacation.

Mr. COUCHMAN seconded the resolution.

The CHAIRMAN said it was probably desirable that he should offer a word or two of explanation as to the present position of the Company so far as related to the liquidators of the old Company. The property of the present Company had never been assigned to it by the old liquidators, so that any assets realised by sales of the Company's property, as the Board had been informed on the preceding Tuesday, were required by the old liquidators to be deposited at the Company's bank, pending settlement of the action with Mr. Watts. He could not altogether reconcile the wish of the liquidators with their action and statements in the past, because the Board were in the first instance told that £1,000 would cover everything required. Afterwards they were informed that £2,000 would be required; but now they were told that any liquidators of the new company selling its effects could not touch one farthing of the proceeds. The Company was therefore practically at the mercy of the old liquidators, and he was unable to congratulate the shareholders on the position in which they were placed—it was a position in which he did not feel at all comfortable.

A SHAREHOLDER: Who is responsible for the Company being at the mercy of the old liquidators? I hardly understand the matter.

The CHAIRMAN: I should say the solicitors of the present Company are responsible.

Mr. DAVIS, the Solicitor: Why, Sir?

The CHAIRMAN: Because they have never required the old liquidators to convey to the new Company.

Mr. DAVIS: That is not a fact, Sir; and I am surprised that you should say so.

The CHAIRMAN: We cannot fix the responsibility on any other person, but we shall be happy to hear what you have to say.

A SHAREHOLDER: I think we should have some explanation.

The CHAIRMAN: Mr. Davis says my statement is too bad; but, looking at the matter from a common-sense point of view, it is clear that the solicitors should see that this Company was conveyed to the present shareholders.

Mr. DAVIS contended that the Company had had everything. Anything the liquidators recovered was for the benefit of the present Company. But the liquidators must be indemnified by the new Company for the cost of the action in the event of its being lost. The shareholders could not make the liquidators personally liable for the costs and responsibility of the action.

The CHAIRMAN submitted that Mr. Davis was speaking entirely after the event. It could not be foreseen that the Company was coming to grief, and that only a few hundred pounds would be left for the expenses of the action. He considered that the solicitors should have seen that the effects were legally assigned to the new Company.

A SHAREHOLDER imagined that when the new Company was formed some agreement or contract was made defining the relation of the liquidators of the old Company towards the Directors of the new Company.

The CHAIRMAN observed that the liquidators would not assign, except under certain conditions. It was true that the interest of the old liquidators and the interests of the new Company were apparently identical; but the Company had as liquidators of the old Company representatives whose services on the Board had ceased to be required.

Mr. DAVIS said the liquidators had no interest in opposing the Company. If they won the action against Mr. Watts the sum of £4,000 or £5,000 would become the money of the shareholders, and that the Chairman's statement was worse than nonsense.

The CHAIRMAN said a contract in reality existed subject to certain conditions, which the Board had fulfilled. They were asked to place £1,000 to the credit of the old liquidators, but they now found that they could not deal with any of the Company's property. Subsequently a sum of £2,000 in all was required. After the present meeting the shareholders would see no more of him (the Chairman) in connection with the business of the Company. He had lost money by it, and he had made enemies by it.

Mr. DAVIS said the liquidators had been perfectly prepared at any time to assign, but in doing so they would have taken very good care that the shareholders deposited a sufficient sum to indemnify them in the case of losing the action. They would have been prepared to assign at any time, but as the assets of the new company had always been liable to the old liquidators, the latter in assigning them would have required security for costs to be incurred.

A prolonged discussion ensued, opinion being expressed by several shareholders that there was scope for business before the Company if a satisfactory solution of the difficulty could be found. Reconstruction was suggested; and Mr. NEWTON pointed out that as the Company could meet all its liabilities it was not insolvent, and that the resolution in that respect was inconsistent. The CHAIRMAN pointed out, however, that the Company could not continue business, and, finally, the resolution was adopted.

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The CHAIRMAN proposed that Mr. Marks and Mr. Hodgson be appointed liquidators; and Mr. HAMBLIN moved, as an amendment, the appointment of Mr. Newson Smith. The amendment was defeated, however, and the remuneration to be paid to the liquidators was deferred for future consideration.

A vote of thanks to the Chairman closed the proceedings.

Keswick Electric Light Company (Limited).

The half-yearly meeting of this Company was held this week, and we have been furnished with the following report of the proceedings thereat:—

Mr. R. D. MARSHALL, J.P., occupied the chair, and said that there was no business to bring before the meeting, but he would be pleased to answer any question which any shareholder might put regarding the capital, expenditure, or working expenses. The balance-sheet would be placed in their hands at the end of the year. He might say that the accounts showed that for the first five months they had paid their way, though the income due from the consumers for that time was much less than it would be during the next six months. The light seemed very popular, and was quite satisfactory. They had many more lamps applied for than they could supply with their present machinery, and the question of enlargement of the station was being considered.

Messrs. Fawcus and Cowan's (the engineers) report was then read:—They said that the running of the machinery had been up to the present time quite satisfactory in every respect. The engine, which had been installed as a stand-by, had only been run twice during a short time, and then it was not on account of shortness of water for the turbine, but to help the turbine on the occasion of an exceptionally heavy load during the Keswick Convention week. It was found that the consumers were at present rather extravagant with the light, but it was hoped that as the novelty wore off they would be more careful to switch off all lights not actually in use.

A few questions were put by a SHAREHOLDER respecting the charge for the light, the CHAIRMAN remarking that the price was, as far as he had ascertained, lower than in any other town supplied by a central station.

After which the meeting terminated.

City and South London Railway Company (Limited).

The following is the report of the Directors of this Company (formerly the City of London and Southwark Subway Company) to the shareholders, at the twelfth half-yearly ordinary meeting to be held at Winchester House, Old Broad-street, E.C., on Tuesday, the 12th August, at 12 o'clock noon.

During the past half-year both of the tunnels have been completed, the whole of the permanent way laid, and the underground stations finished with the exception of tiling, painting, and other small matters. The surface stations and the lifts are rapidly approaching completion, and the hydraulic pipes and electric conductors are laid throughout.

At Stockwell Depôt the inclined road leading to the tunnels is finished and in use, the two engines and dynamos for the electric power are completed, and the third or reserve engine and dynamo is nearly ready; the three engines in connection with the hydraulic power for working the lifts are also ready, and the engine-house and carriage stores are roofed in. A portion of the rolling stock is ready for delivery, and it is expected the railway will be opened for public traffic at an early date.

The Bill for the extension of the line to Clapham has passed through Parliament and received the Royal assent. By it the name of the Company is changed to the "City and South London Railway Company."

The Bill referred to in the last report, and known as the Central London Railway Bill, was thrown out in the House of Lords. Your Directors will have to consider how far some of the advantages proposed by that Bill could be usefully provided by this Company without the objections urged against that measure.

To meet the wishes of many of the larger shareholders, notice has been given of a resolution to convert the share capital of the Company into Stock, so as to facilitate its transfer.

NEW COMPANIES REGISTERED.

BRITISH GAS LIGHTING IMPROVEMENT COMPANY (LIMITED).—Registered with a capital of £160,000, to carry on the business of mechanical, gas, and electrical engineers, and manufacturing chemists in all branches.

MULHOLLAND, MAUGHAM AND CO. (LIMITED).—Registered with a capital of £5,000, to take over the business of R. M. L. Mulholland and B. Maugham, at Ferryhill, Durham, trading as Mulholland, Maugham and Co., and to manufacture and deal in apparatus and things required in connection with electrical engineering, and in particular to construct and lay down cables.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended July 25th amounted to £5,114.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of July were £3,150, as compared with £3,003 in the corresponding month of last year. The receipts for the month of April, estimated at £3,600, realised £3,624.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The estimated traffic receipts for the month of July are £2,016, against £1,677 in the corresponding period of last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of July amounted to £54,224, as against £54,248 for the corresponding period of 1889.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic returns of this Company for the month of July are £46,367, as against £42,876 for the same period last year.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in July, 1890, £25,600; January 1 to July 31, 1890, £156,000. Corresponding months in 1889 and 1888, £154,200 and £156,000 respectively.

NORTH METROPOLITAN TRAMWAYS COMPANY (LIMITED).—At the meeting of this Company, held at the Cannon-street Hotel on Wednesday, the Chairman said that the Directors had applied to the local authorities for power to use electricity, but at the same time they did not intend to experiment with the shareholders' money; but if anyone came forward and proposed to effect an installation, every facility would be given. The electric traction at Barking had been working satisfactorily, the General Electric Power and Traction Company having run 44,047 miles during the half-year, for which they were paid 4½d. per mile. A resolution declaring a dividend of 10 per cent. was carried.

NOTTING HILL ELECTRIC LIGHTING COMPANY (LIMITED).—In the matter of Thomas v. the Notting Hill Electric Lighting Company, Mr. Maclean, Q.C., on Wednesday, stated before Mr. Justice Chitty that the parties to the motion, which was one for an injunction, had consented to an order on terms.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this Company for the month ended July 31, 1890, amounted to £5,825.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The receipts of this Company for the half-month ended July 31st show a decrease of £1 as compared with the corresponding period.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 1, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,921.

WESTERN COUNTIES AND SOUTH WALES TELEPHONE COMPANY.—The dividend warrants for the interim dividend on the Preference Shares, of 6 per cent. for the half-year ended June 30th, were posted on Saturday last.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended July 31st amounted to £2,671, as compared with £2,672 in the corresponding period of last year.

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The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, July 30.	Price Wednesday, Aug. 6.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 6. Highest.	Lowest.
£			**TELEGRAPHS.**			£ s. d.			
1,381,380	Stock	15/0	Anglo-American ..... xd	50 51	49½ 50½	5 8 11	Jan., Apr., July, Oct	.. ..	.. ..
2,809,310	Stock	30/0	Do. Preferred ..... xd	86½ 87½	85 86	6 7 11	" "	86	85¼
2,809,310	Stock	..	Do. Deferred	13¾ 14¼	13¾ 14¼	..	..	14⅛	13⅝
25 ,000	£100	4%	African Direct, 4 per Cent. Debentures	97 100	97 100	4 0 0	January and July ..	98½	..
130,000	10	3/0	Brazilian Submarine	11½ 12	11½ 12	5 8 4	Mar., June, Oct., Dec.	11⅝	..
69,200	100	5%	Do. 5 per Cent. Bonds ..... xd	102 104	100 102	4 18 0	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103 107	103 107	4 13 6	June and December	..	..
..	$100	..	Commercial Cables	112 116	103 105	..	..	103¾	..
16,000	£10	9/0	Cuba Submarine	12¾ 13¼	12¾ 13¼	6 15 10	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	17⅞	17⅝
12,931	5	2/4½	Direct Spanish (£4 paid)	3½ 4	3½ 4	..	March & September	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October ..	9¾	..
60,710	20	3/6	Direct United States ..... xd	10⅜ 10⅝	10½ 10⅝	6 15 0	Jan., Apr., July, Oct.	10⅝	10⅞
400,000	10	5/6	Eastern ..... xd	14 14¼	13⅞ 14⅛	4 12 0	" "	14⅛	13⅞
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	15 15½	15 15½	3 17 5	" "	15½	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106 109	106 109	3 13 5	May and November	..	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899 ..... xd	108 111	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14 14¼	14 14¼	4 18 3	Jan., Apr., July, Oct.	14⅛	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891 ..... xd	101 103	100 102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	103	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	100 103	100 103	4 17 1	" "	..	..
180,227	10	4/3	Globe Telegraph and Trust ..... xd	9⅛ 9⅜	8⅞ 9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference ..... xd	15⅛ 15⅜	14⅝ 15⅛	3 19 4	" "	15⅛	14⅝
150,000	10	5/0	Great Northern	15½ 16	15½ 16⅛	4 12 4	Jan., April, and July	16⅛	15⅝
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100 103	100 103	4 17 1	January and July ..	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883..... ...	106 109	106 109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	37 39	37 39	6 8 2	April and October ..	38½	38
38,348	10	4/0	London Platino-Brazilian	6 7	6 7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107 110	107 110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞ 8¼	7⅞ 8¼	6 1 3	April and October..	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	112 116	112 116	..	" "	..	..
15,609	£10	6/6	West African	9 10	9 10	5 0 0	.. ..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	100 103	100 103	4 17 1	March & September	..	..
30,000	10	3/0	West Coast of America ..... xd	5 6	5 6	..	January and July ..	5½	..
150,000	100	8%	Do. Debentures 8%	106 110	106 110	7 5 6	June and December	..	..
88,321	10	Nil.	West India and Panama	2½ 2⅝	2⅝ 3	..	..	3	2⅝
34,563	10	6/0	Do. 1st Preference 6%	11 11½	11½ 11⅝	5 2 2	April and October..	11⅞	11½
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12½ 13½	12½ 13½	..	..	..	..
64,572	15	6/0	Western and Brazilian	10 10½	10 10½	5 14 3	May and November	10¼	10
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½ 7	6½ 7	..	..	..	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	3¾ 4¼	3¾ 4¼	..	..	4	..
200,000	100	6%	Do. 6 per Cent. Debs., Series "A" .....xd	106 109	103 106	5 13 2	.	104½	103½
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"..xd	104 107	101 104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99 101	99 101	5 18 10	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5¾	Consolidated Telephone Const. and Maintenance..	1⅛ 1¼	1⅛ 1¼	..	Yearly	⅞	..
220,000	£1	3%	Oriental (11s. paid)	⅜ ⅝	⅜ ⅝	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅝ 5⅛	4⅝ 5	6 0 0	June and December	5	4⅞
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12¼ 12⅝	12¼ 12⅝	4 14 1	June and December	12⅛	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10 10⅛	10 10⅛	4 15 3	" "	10⅛	..
209,750	1	⅛%	South of England, Ordinary ..... xd	⅛ ⅜	⅛ ⅜	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd).xd	2⅝ 3¼	2⅝ 3	..	..	..	..
55,000	5	1/0	United River Plate ..... xd	4 4⅛	4 4½	..	..	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	January and July ..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	1⅞ 2	1⅞ 2	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4 4⅛	4 4⅛	..	..	..	..
42,853	5	..	Westminster Electric Supply	1¼ 1⅜	1¼ 1⅜	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	1⅞ 2	1⅞ 2	..	..	1⅞	..
63,416	2	1/2	Do. Preference	1⅜ 1⅞	1⅞ 2	..	..	1⅞	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares....xd	5¼ 5⅜	5½ 5¾	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction	7⅞ 8¼	7⅞ 8¼	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing.....xd	5 5½	4 4½	..	..	4⅜	4¼
20,000	5	..	Fowler-Waring Cables	2 2⅜	2 2⅜	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	18½ 19½	18½ 19½	5 2 7	February & August	..	..
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5 5½	5 5½	3 16 5	..	5½	5⅛
37,350	12	12/0	Telegraph Construction and Maintenance.....	42 44	42 44	5 9 3	March and July.....	43½	42
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894.....	100 102	100 102	4 18 0	..	..	..

JABLOCHKOFF'S DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

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NOTES.

We learn from our New York correspondent that the Postal Telegraph scheme is again before the United States Congress, but again with as little prospect of any serious progress being made in that direction. It surprises us somewhat that the experiment has not been tried on a comparatively small scale by one or other of the States, each of whom possesses a sort of independent government. But we presume that the radical objection to this much-needed undertaking is the same for the separate States as for the whole country, namely, the political character of all their executive and administrative departments. For the telegraphs certainly a change of officers, such as takes place in the Post Office and other public departments, with every change of President would be an impossibility; and until the United States consents to reform its political institutions any change in the status of the telegraph service is not to be hoped for. For a nation that prides itself on being ahead of the universe the confession that "we are not yet ripe for such a radical change" is a very humiliating one, and one which helps us to regard with complacency the less democratic institutions of the old world, where professional politics have not yet invaded the public service.

Candid critics will probably acknowledge that, so far as regards simplicity and the elements which bear on the question of efficiency, the design of the new American dynamo which we illustrate this week is a good deal behind that of the English one which accompanies it. The dynamo of Prof. Elihu Thomson was mentioned by our American correspondent in his New York letter of last week. The description reminded us at once of Mr. Mordey's work, but we were hardly prepared to find in the two leading American electrical journals, and announced as extraordinary and revolutionary, an illustrated account of a machine the principle of which resembles so closely one of the forms proposed by Mr. Mordey. The English inventor described a number of methods of constructing dynamos in which the magnetic induction through the armature coils is altered by means of a moving "keeper." An interesting feature in the English design is that the arrangement is such that no back volts are set up in the field coil, although it is engaged in magnetising a laminated iron structure, all the parts of which are undergoing violent periodic changes of magnetisation. We understand that, in spite of its great simplicity, Mr. Mordey did not put into practice that particular design, which is one of many changes which he rings on this theme in his patent, because there is iron in the armature. And with regard to simplicity, it will be remembered that he followed up on the same line of development, and showed at the Institution of Electrical Engineers a model of a still simpler form of machine. We are not so convinced of the evil effects of iron in the armature as is Mr. Mordey, although it must of course be acknowledged that absence of iron in the armature means reduction of losses. His arrangement of the field coils and magnetic circuit is much superior to that of Prof. Thomson, whose design includes a magnetic circuit to which many objections may be raised.

It is somewhat strange that since the chief object of electric lighting is to produce illumination, the subject should be so little studied; and it is to be hoped that we may before long have definite specifications of the amount of illumination that is desirable for different purposes and localities. We have analysed in another column some of the recent work of M. de Nerville, who advocates the "bougie-metre" as a unit of illumination. This is the same as the "deci-lux," the tenth of the "lux," which was suggested in 1884. We take from the *Gas World* of last week an abstract of an article by Prof. Leonhard Weber, of Breslau. This abstract, which has apparently suffered considerably in abridgment, gives some interesting estimates of the relative brightness of various sources of illumination and of illuminated surfaces. It would appear that we have less occasion to grumble about the inability of our eyes to detect a difference of less than 2 per cent. on a photometer screen (and many of us cannot recognise 4 or 5 per cent.) when we find that the range between a sheet of printed paper, so lighted that it is just possible to be read, is some thousand millionfold less bright an object than the noonday sun. Prof. Langley, if we remember rightly, has arrived at a similar estimate. In connection with the same subject, an account of the arrangement of both arc and glow lamps in textile factories will be found in another column, and a description of the Siemens-Violle standard lamp.

It is very difficult to determine the degree of accuracy with which photometric measurements of illumination should be carried out. There is more than one serious obstacle to anything like the precision that is aimed at in most physical measurements. The ratio of the rays transmitted by the red and by the green glasses compared with sunlight does not, of

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course, measure the relative amount of red light and of green light of the sun, but of the standard lamp or candle used in the photometer. But a new difficulty presents itself which does not appertain to the instrument or to the sources of illumination which are compared by it. Prof. SCHUSTER, in the last number of the *Proceedings* of the Royal Society, describes some experiments made with Lord RAYLEIGH'S colour box. He submitted to a considerable number of persons a pure yellow image, from the D part of the spectrum, and a compound yellow composed of a full red near C, and a green of wave length 562. By means of a Nicol prism each person could mix the red and green components together in any proportion; and they were asked to make the compound yellow match the simple colour. By plotting the number of observations for different proportions, a curve of the nature of a probability curve, but with some marked characteristics, was determined. The apex should show the normal proportion. This apex is not well defined, and the curve is irregular, but the remarkable point about it is its extraordinary range. One observer required 2·8 times as much red as green to make the match, while another took five times as much green as red to produce the same tint. Under these circumstances anyone using a photometer in which coloured glasses are used should satisfy himself that his eyesight does not differ much from the normal. We would suggest that Mr. GALTON should add a colour box to the instruments at the public anthropometrical laboratory at the Science Collection at South Kensington.

THE issue of the prospectus of a Sectional Boiler Company reminds us that a thorough comparison of the advantages of sectional and Lancashire boilers has never yet been made. The Babcock-Wilcox boiler has been largely employed for electric lighting purposes, and some of its merits are obvious, while there are points in which it cannot compare with a shell boiler. We have yet to hear a complete Paper on the subject at the Institution of Civil Engineers, and we hope that such a Paper may be prepared by some engineer who has had ample experience of both kinds. The elaborate report of Mr. LONGRIDGE, which appeared in *Engineering* last month, describing a trial of a Babcock-Wilcox boiler, is of little use for purposes of comparison, and the author did not undertake to offer criticisms of any moment; indeed, the Paper concludes with the observation that the balance sheets of the tests call for no remark. This is leaving half the work undone. The report has given rise to a few letters in the columns of our contemporary, but it is to be regretted that up to last week they do not amount to a discussion. The new Sectional Boiler Company sets out 27 advantages, of which 16 are comparisons with other tubular boilers, and the remainder relate to Lancashire boilers. Statements of this kind in a prospectus do not carry much weight, but they may at least be taken as indicating the direction in which advantages may be found. The Babcock and other tube boilers have been used largely in America, and Bellville boilers are very commonly employed in France. We believe this may be accounted for to no small degree by the facility which such a boiler offers for transport when packed in for delivery. It can be handled in small parts, and it is easily erected. These advantages do not carry so much weight in this country where the railway companies are quite familiar with the carriage of boilers by rail and road. One of the engineers whose report is quoted in the prospectus, says that the new patent boiler gave results "far in excess of anything within my experience, certainly 15 per cent. better than the ordinary Lancashire boiler . . . and 32 per cent. better than that obtained by Mr. LONGRIDGE . . . with a Babcock-Wilcox." This is rather a side cut at the well-known steam generator. No mention is made of the kind of Lancashire boiler; and considering how very much these vary on account of the different conditions of working and use, it may be doubted whether the new patent will do better duty than the best productions of Galloway.

IN noticing the last number of the *Quarterly Journal* of the Massachusetts Institute of Technology, we drew attention to the splendid equipment of the engineering laboratories of that Institute. In the Notes will be found an abstract of an account of the Electrical Engineering College of Princeton, New Jersey, and a brief description of the course of instruction given there. From the clever illustrations in our American contemporary, the laboratories and shops do not appear to be very large, and we doubt if they could comfortably accommodate the students of the Finsbury Technical College, who manage to work with a minimum of elbow-room. The text-books include the works of MAXWELL, CUMMING, STEWART and GEE, KOHLRAUSCH, SLINGO and BROOKER, GRAY, S. P. THOMPSON, KAPP, and Dr. FLEMING'S "Alternate-Current Transformer," the latter being "read for four hours a week for half the year."

West Cowes.—The Local Board recommend that sanction should not be given to the application made by the Electric Light and Power Supply Corporation to the Board of Trade for providing light in this district.

A New Telpher Line.—The Telpher Railway at East Pool is now complete. A trial was made on Friday last week in the presence of a large number of persons interested, when its working was declared to be perfectly satisfactory.

Electric Lighting in Berwick.—The Northern Electric Light Company intimated on the 12th inst. to the Berwick Urban Sanitary Authority their intention to apply to the Board of Trade for powers to supply electric light in Berwick.

Electric Tramway without Grooved Rails.—Messrs. Merryweather and Sons, writing to the *Star*, say that some important experiments are taking place at their Greenwich works in connection with this subject, whereby the grooved rails are dispensed with.

Liskeard.—At the quarterly meeting of the Town Council on Tuesday, it was decided "that a Committee be appointed, with powers to incur expenditure in getting the opinion of experts in lighting the town either with gas or electricity, and the cost not to exceed £20."

Accumulator Tramcars in America.—The Union Electric Car Company have been running cars weighing six to seven tons, with a charge that will drive the vehicles for 30 to 40 miles. The trolley wires and feeders and turnouts are being recognised as unsightly and dangerous in Boston.

Electric Lighting at Konigsberg.—The work of laying the mains is now nearly finished, and connections with the houses will be commenced at once. The Mayor has decided that the lighting shall start on October 7th. This will only extend to the central portion of the city, though that of the lower town will follow in the course of a few weeks.

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Budapest.—Messrs. B. Egger and Co. have in view the lighting of the block of buildings bounded by Dorothea, Wurm, and Valerie-streets, and Franz Joseph's Platz. The first installation will include plant to the extent of 300 horse-power, together with the usual battery of accumulators.

Llanelly.—At the monthly meeting of the Local Board of Health, on Tuesday, it was resolved that the resolution of the Board giving permission to a local company to apply to the Board of Trade for a licence to light certain districts of Llanelly with electricity be rescinded, and it was subsequently decided that the Board apply for powers themselves.

The Gas of Cork.—Mr. Denny Lane, Secretary of the Cork Gas Consumers' Company, writes to point out that the remarks of the Judge to which reference was made in last week's issue, related to some Argand burners which were suited for burning cannel gas, but were unfit for ordinary gas. The Cork gas is 16½ candle, instead of 14 candle, according to the local Act of Parliament.

Glasgow Electric Tramways.—At the Glasgow Town Council on Wednesday it was stated that a letter had been submitted from the Electric Tram Car Syndicate bringing under the notice of the committee their system of electric traction. After some discussion it appears that it was decided to acquire the Ibrox Tramway Company's lines, and work them in connection with the Glasgow tramways.

Berlin.—From the *Elektrotechnische Zeitschrift* we learn that the lighting of the suburb of Grunewald by the Kurfürstendamm Company will be at once proceeded with, although a more suitable site for the central station is to be desired. The streets are to be lighted with incandescent lamps, 12 amperes. The total cost, inclusive of buildings, is estimated at 300,000 marks (£15,000).

Municipal Lighting at Kassel.—At Ostheim's mill, which, as we announced in our last issue, has been purchased by the authorities, there is available, besides the water power, steam plant to the amount of 120 horse-power. These will be used to drive alternators, and at the central station in the town alternating-current motors will drive continuous-current dynamos, which will supply the lights and charge accumulators.

Coal-cutting Machinery.—Several patents have been taken out in the United States lately, by Van Depoele, for coal-cutting machinery, but all of them are of a reciprocating character, a so-called magnetic piston working in a number of coils. It is very unlikely that this plan will give satisfaction, for though it may directly give the required motion of the tool, it is the wrong way to produce motion on a large scale by electricity.

Fulham.—The Vestry has resolved to take the necessary steps through the Lighting Committee to prevent any of the companies obtaining powers to supply the electric light in Fulham. The application of Mr. S. Morse, on behalf of the Chelsea Electricity Supply Company (Limited), for permission to obtain a Provisional Order, authorising them to run electrical trams through the parish along the Fulham-road and King's-road, has not been acceded to.

Telegraph Clerks.—Sir H. Maxwell (on behalf of Mr. Raikes), in reply to Dr. Farquharson, said that much attention had been given to the question of overtime, with every desire to lighten its incidence; but no one, either on the part of the Post Office or on the part of the officers themselves, has been able to suggest any practicable scheme for getting rid of these duties. This matter formed an element of consideration in improving the pay under the scheme recently issued.

Electric Motors in America.—The Rochester Brush Company, driving dynamos from the falls of the Genesee river, have 500 motors at work. 108 tailors' shops are supplied at the rate of £3. 15s. per annum for ⅛th of a horse-power. Ventilating motors are run continuously from June till October for £3. 2s. 6d. One horse-power per day is supplied for a shilling. Two horse-power per annum, £25; five horse-power, £52; eight, £83; and 15 horse-power, £146.

Telephonic Communication with Harbours and Roadsteads.—Manilla was to have made the first move in this direction in the East, although the matter seems to have been spoken of at Madras. *Indian Engineering* hears that the Telephone Company at the Port of Manilla has taken measures to open a floating station in the harbour, so as to admit of vessels communicating with the city, thereby benefiting people on board by saving them the trouble of going personally ashore.

Telephones on Ben Nevis.—Mr. Erskine Mudehead has offered to erect at his own expense a set of "Ader" telephones on Ben Nevis. These will connect the summit and the low-level observatories, but at present the Telephone Companies block the way. It often happens that for two months communication with the summit of Ben Nevis is cut off, so that the new method of intercourse between the occupants of the observatory and Fort William will be very welcome.

Harrogate Town Council.—A quarterly meeting of the Harrogate Town Council was held on the 12th inst. A number of companies having given notice to the Corporation that they would seek powers for the purpose of lighting the town with electricity, the Town Clerk reported that the notices were in the hands of the borough solicitor, who was instructed to take all necessary steps with regard to the same, in order to prevent the companies obtaining the powers which the Corporation hope in the near future to obtain themselves.

The Life of Lamps.—A very notable case of lamp endurance is reported by the *Electrical World* from Albany, Georgia, where, in a restaurant using nine 32 candle-power lamps, and one 50 candle-power, but one new lamp has had to be put in for a year and a-half, or during an actual lighting of 3,500 hours. If this record is authentic, the lamps in question certainly deserve their name of "Edison High Economy"; but there is no mention of the voltage used. A slight variation from nominal voltage explains many phenomenal records.

Lighting of New York.—It appears from a report upon the tenders for lighting the streets of New York by electricity that there was no regular combination among the electric companies to keep up the prices, as far as could be discovered by any examination of the figures. The fact remains that all the tenders were very high, and the question of reverting to gas in a number of streets is being considered. The reason is no doubt due to the removal of so many overhead wires, and the absence, at present, of the necessary conduits under the streets.

Telegraphs in China.—It is announced with an appearance of authority, says *The Times*, that the Telegraph Convention between the Chinese telegraph administration and the Great Northern and Eastern Extension Cable Companies, for maintaining a uniform rate for messages between China and the rest of the world, will not now be ratified. It appears that Li Hung Chang (like the late Marquis Tseng) has thrown his weight against the Convention, on the ground that it would be derogatory to China to give up her independence in this matter in return for an annual subsidy.

Utilising Scrap Steel Rod.—The Thomson Electric Welding Company has built a machine especially for the welding of scrap steel to be drawn into fence wire. The Illinois Steel Company has tons and tons of steel rod scrap which it has been obliged to melt over in order to utilise it. The Company invited the Welding Company to experiment with this scrap, which it has done successfully, and it will now build machines for practical work. The machines will yield the company $1,200 (£336) advance minimum rental, and a royalty of 1 cent. per weld during the life of the patents.

The Lighting of the House of Commons.—In reply to Sir G. Campbell, who asked the First Commissioner of Works if he would arrange before next Session to put shaded electric lights in the roof of the House so as to save members from the heat and glare of the gas in the long winter nights, and make the nearest possible approach to daylight, Sir H. Maxwell said, on Friday last, that the electric light was tried in the roof of the House some time ago, but the results were not satisfactory. The present gas lights were connected with the ventilation, and it would be inconvenient to dispense with them.

Electric Traction at Hammersmith.—In spite of the wishes of the adjoining Vestries of Chiswick and Brentford, the Vestry of Hammersmith continue to maintain a hostile attitude to the use of electricity on the tramway in that district. Mr. Lineff abandoned the slotted conduit on which the first ostensible objec-

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tion by the Vestry was based. The system which has recently been described has been sanctioned by the London County Council and the Board of Trade, and by the Vestries concerned, but, according to a characteristic article in the *Star*, which broadly hints that such things are arranged by fees to the vestrymen, further progress is still blocked by the local authority.

Is Electricity Manufactured?—The Courts of Pennsylvania are trying to settle the question whether or not electric light companies are manufacturing companies. Manufacturing companies, says the *Manufacturers' Gazette*, of Boston, are exempt from taxation in that State under certain conditions, and the Courts hold that electric light companies do not manufacture anything, that electricity is not manufactured—they do not manufacture light. The question will probably be carried to the highest Court before being settled. As manufacturing consists of increasing the value of raw material, electric light companies do not come within the meaning of manufacturing.

Two Large Electric Cranes.—Two travelling cranes, which in some respects will be unlike any others yet constructed, are to be put into the Baldwin Locomotive Works by Messrs. Wm. Sellers and Co. They are, according to *Iron*, each to be of 100 tons capacity, with a span of 75ft. 4in. and 336ft. run, and are to be driven by electricity. The maximum speed of the bridge travel will be 200 per minute, trolley travel 50ft. and 100ft., and main hoist speeds 5, 10, 20, and 40ft. per minute. It is the intention to handle and transfer from one track to the other the heaviest locomotives complete by means of these cranes, while for handling parts and lighter loads there is an auxiliary hoist capable of lifting 1,000lb. at a speed of 100ft. per minute.

Telephone Communication with Telegraph Offices.—In France, as in England, there are a great many hamlets and villages to which the network of telegraphs has not yet extended, and persons living there are obliged to pay a heavy fee for the carriage of a despatch from the nearest telegraph office. In France a measure has, according to the *Pall Mall Gazette*, just been decided upon which will reduce this fee to 2½d., and at the same time almost entirely do away with the delay occasioned by the carriage of the despatch by hand. All communes which have not a telegraph office are to be connected with one by telephone, through which the despatches received by telegram will be forwarded verbally, the despatch being later on ent by post.

St. Moritzbad.—The scheme which has been abandoned at this place by the advice of the well-known engineer, Mr. Uppenborn, who was consulted as an expert, as not being suitable for the case, was the project for using four continuous-current high-speed dynamos, of 2,000 volts each, coupled together in series, and not the alternating-current proposal, as erroneously stated in a Note last week. The Editor of the *Elektrotechnische Zeitschrift* is good enough to inform us that the plans of the firm of Stirnemann and Weissenbach, of Zürich, with some modifications, have been adopted. Three Girard turbines, with horizontal shafts, are coupled direct to alternate-current machines, made by Messrs. Ganz and Co., of Budapest. These give a pressure of 3,000 volts, and the current is conveyed to the hotels by a copper circuit of about 9 kilometres, and is there transformed to 100 volts.

The Thomson-Houston Electric Coal-cutting Machine.—The Thomson-Houston Company has put one of their coal-cutting machines into operation near Osceola, Penn. The cutter, which is operated by a five horse-power motor, is nearly a mile from the generating plant. The cutter itself consists of an iron frame 24in. high, 8ft. 6in. long, 30in. wide. Nine auger-shaped drills similar to those now used in mining are placed in the lower part of the frame. Between each drill is a steel cutter bar which cuts all coal left between the holes drilled by the auger bits. On the under side of each cutter bar are attached several scrapers, which hang loosely and pull all the coal back as soon as it is cut or drilled, keeping it out of the way and making the opening clear. The height of the cut is four inches, and the machine makes two cuts in five minutes. The weight of the complete machine is a little over half a ton. The motors are wound for but 220 volts pressure. The capacity of the machine in question is 160 tons of coal per day of ten hours in a four-foot vein

Electric Light in Churches.—Arrangements for the complete lighting of the Church of St. Jude, South Kensington, by electricity have just been concluded between the vicar and churchwardens and the House-to-House Electric Light Supply Company (Limited), of Richmond-road, West Brompton. The installation is to consist of 275 incandescent lamps of 8 candle-power, the existing gas fittings being utilised in nearly every instance for the distribution of the light. The nave, for example, will be lighted by 144 lamps, 12 lamps to each of 12 coronas; the chancel will absorb 66 lamps, 30 on two standards in front of the altar, and 36 on four standards for the choir stalls. Eighteen lamps will be distributed on brackets round the galleries, and 28 for the lighting of the aisles. There will be five lamps within and about the organ, one of them being a portable lamp, to facilitate tuning operations, &c., without the danger involved in the use of matches and of exposed gas burners. The remaining lamps go for the lighting of the vestry, gallery stairs, &c. The whole installation will be completed, connections made with the company's mains, and the current supplied within about a month.

Hammersmith Electric Lighting.—The Law Committee of this Vestry had under consideration a letter from the Board of Trade, enclosing copy of a letter they have received from Woodhouse and Rawson (Limited), and asking for the observations of the Vestry upon the matter. The Committee recommend the Vestry, in answer to the letter from the Board of Trade, to consent to the application of Messrs. Woodhouse and Rawson to purchase from the West Middlesex Electric Lighting Company the undertaking authorised by the Fulham District Electric Lighting Order, 1884, subject to their agreeing with the Board of Trade, and the Vestry to be bound by and subject to all the latest provisions required by the Vestry, and also to their undertaking to apply in the next Session of Parliament for a Provisional Order embodying all such provisions; and also subject to their paying all legal and Parliamentary costs already incurred by the Vestry in connection with previous applications and to be incurred during the next Session in connection with the proposed application; and in the event of the order being sanctioned, the works to be proceeded with within three months after such sanction.

Telephone Trunk Lines.—A telephone map of the north of England is covered with lines representing trunk wires between the various towns, and it is possible for conversation to be carried on between nearly all towns of importance. Out of Manchester there run, says *Engineering*, no less than thirty-five wires: four to Glossop and Sheffield; five to Stockport, and thence in decreasing number to Macclesfield, Congleton, Newcastle-under-Lyne, Birmingham, South Wales, and London; four to Warrington; nine to Bolton; three to Bury; seven to Middleton and Rochdale; three to Oldham. There are fifteen wires out of Liverpool; twenty-one out of Bolton; nine out of Preston; sixteen out of Blackburn; twelve out of Todmorden; twenty out of Bradford; eighteen out of Leeds; sixteen out of Dewsbury; fifteen out of Sheffield; fifteen out of Derby; twelve out of Nottingham; thirteen out of Stockton; twenty-three out of Newcastle; and many others. The London subscriber to the telephone will say that things must be better managed in the North than in the metropolis to render it possible to hear over such long distances. However, he will soon have an opportunity of putting the matter to the test, for London will be joined within the next few months to all the towns we have mentioned.

Lifts worked by Electric Motors.—At the Demarest Building, Fifth Avenue, New York, are two lifts, capable of raising 16¾ cwt. 110 feet per minute. The motor is so coupled to the lift gear that it starts and stops with the winding machinery under control of the attendant in the car, thus forming a single apparatus, free from jerky and irregular running of detached gearing, as when worked by belts. The controlling rope is connected with the switch and the brake by means of the steel bar running across the base of the apparatus. An indentation in this bar (into which a wheel supporting the brake-weight settles when the current is turned off) makes simultaneous the action of brake and switch. When the switch is at centre the brake is lowered into the

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indentation in the bar, and the weight, applied directly to the armature shaft, stops the motion of the armature. When the steel bar is moved in either direction the current is turned on and the brake raised. The current is supplied from the Twenty-sixth-street Edison station at 220 volts. The armature makes 800 revolutions per minute, and is connected by worm gearing to the winding-drum, which revolves ten times a minute. Heating and "burning out" have been guarded against in the construction of this machine, and an indicator is employed which shows the operator in the car the position of the controlling and reversing switch on the motor.

The Kimberley Electrical Tramways.—The opening ceremony of the Kimberley Electrical Tramway took place on the evening of July 17th, and is thus described in the *Diamond Field Mail Summary*:—"The ladies having taken their seats inside the car, the imposing-looking vehicles moved majestically out of the depôt guided only by the delicate hand of Mrs. John Gibson. A bottle of champagne was broken on its ample front as it emerged from under cover." . . . "In the early part of last year Mr. John Gibson proceeded home and travelled throughout England and the Continent with the object of finding out the best system of propulsion by electricity. After considerable difficulty he found the firm of Messrs. Mather and Platt, of Manchester, who guaranteed that their cars would run by this system, and the Messrs. Gibson accordingly arranged with that firm to send out a gentleman who would erect the required machinery." English coal at £9 to £11 a ton makes the cost of working by electricity very great on the diamond fields, but of course there is a saving in horses. A shed is provided with long substantial-built tables for the batteries, the car being run in between these tables for changing and putting in fresh batteries. The engine is one of Marshall's compound, with all the latest improvements, and drives one of Mather and Platt's Edison-Hopkinson dynamos. In the car shed is a large acid bath for mixing the acid, lined with thick heavy lead and wooden casing outside, and iron tanks for catching rain water for the use of the batteries.

Horticulture by Electric Light.—In the botanical department of the Cornell University there have recently been made some experiments in the cultivation of plants under electric light, which appear to give results differing from those which Sir W. Siemens obtained. A number of flowers and of vegetables were placed where the rays of powerful electric lamps fell upon them night and day, and their growth is compared with that of others of their own species planted at the same time and under similar conditions, except in the matter of light. The first and most noticeable effect of this treatment is an enormously increased rate of growth. The plants which are lighted seem to work day and night, and to become especially luxuriant in foliage. The vegetables shoot forward with great quickness; peas, for instance, become in a few weeks two or three times as tall as their brethren living by common daylight; and the same thing is true of all the plants. When it came to seeds or fruit of any sort, the matter was entirely different. Here the plants, which had grown slowly and by daylight, were ahead. It is true that the pea which grew by electric light came to bearing much sooner than the other, but its hastily-made pods had very few peas, often only one, and these of an inferior quality. In every instance the reproductive powers of the plant seemed to have been most strongly affected, being sacrificed to mere foliage. It will be remembered that in Sir W. Siemens' experiments, the direct rays of the arc light tended to wither leaves, but this effect was modified when glass was interposed.

The National Electric Light Association.—At the semi-annual Convention to be held on August 19th the following are the subjects of Papers which will be submitted and discussed:—Electrical Industries and the World's Columbian Fair, J. P. Barrett, Chicago; Electric Light as Supplied to Steam Railroads, W. H. Markland, Altoona, Pa.; Standards of Economy in the Generation of Power and Steam under Best Conditions, Editor of *Power and Steam*, New York; Triple Expansion High Speed Engines for Central Station Work, Mr. Williams, Beloit, Wis.; the Model Boiler-room and the Duties of a Fireman, Jarvis B. Edson, New York; Ferranti Station, London, England, Caryl Haskings, Lynn, Mass.; the Proper Care and Management of Alternating Currents, T. Carpenter Smith, Philadelphia; Distribution of Energy by Alternating Currents and Transformers, and the Proper Method of Proportioning Conductors, A. L. Rohrer, Lynn, Mass.; the Proper Basis for Determining Electric Motor Rates, H. L. Lufkin, New York; Actual Cost of Furnishing Arc Lighting (1,200 and 2,000 candle-power lamps) under the Best Possible Conditions, J. C. Ayer, St. Louis; Municipal Ownership of Electric Lighting Plants, M. J. Francisco, Rutland, Vt.; Accidents in Electric Lighting Stations and Plants, Prof. Charles R. Cross, Boston; Care and Labour in Electric Light Stations and its Value, A. J. De Camp, Philadelphia; How Can the National Electric Light Association Best Serve the Interests of Central Station Companies? C. R. Huntley, Buffalo, New York. Reports from the several committees will also be submitted.

The Dennis Iron Tubular Telegraph Pole.—This pole has been designed with the view of providing a strong telegraph pole, which can be, by unskilled labour, easily fixed. The pole consists of three parts:—(1) The base socket of cast-iron, with strengthening webs on the outside, and a pointed end which can be driven into the ground, preferably by means of a small "monkey." For this purpose a gun-metal plug is supplied, which fits into the top of the socket, taking the force of the blow and preserving the casting from injury. (2) The taper tube of wrought iron, slightly coned at its lower end, and fitted at the top with wrought-iron carriers for the usual earthenware insulators. (3) The cast-iron ornamental cap, which forms the joint between the base and the tubular pole. The base socket has a small spigot cast thereon, and the cap has a spiral groove cast therein, in which the spigot can travel. Between this cap and the upper portion of the pole is a liner of asbestos or india-rubber, for the purpose of giving a better grip to the joint. The method of erection is as follows:—The base socket being driven into the ground down to the widest portion of the webs, the cap, with its liner of asbestos, is dropped over the top of the pole. The tube is then lifted on to the socket base, and the groove in the cap is brought into position with the spigot on the base, and by means of a long-handled spanner fitting over the hexagonal portion of the cap, the latter is turned as far as possible. As the spigot is thus made to travel up the spiral groove in the cap, the asbestos liner is compressed, and the whole forms a tight joint. The arms carrying the insulators are clipped round the top portion of the tube, and the pole is complete.

Thunderstorms.—Five persons sought shelter under a tree near Nottingham during the storm on the 11th inst. A flash of lightning was seen, and the whole of the persons standing under the tree were struck down. A man aged 50 and a boy of 11 were killed, and the other three persons were found to be seriously injured. One was unconscious, but hopes are entertained of his recovery. His son and another lad received shocking injuries to their feet. At Mansfield a man aged 69 was struck dead by lightning, and the tree under which he had taken shelter was also damaged. The seam of one of the trousers' legs had been cut open by the lightning, but he did not appear to have sustained any injury except to one of his feet. The residence of the manager at Laird's shipbuilding works was struck by lightning. It demolished a chimney, and passed down into one of the sitting-rooms, which was almost completely dismantled. The mantelpieces were hurled into the middle of the room. In another house the pictures were cleared off the wall, and all smashed. On Monday a flash of lightning made a hole in the roof of a house at Harwich. According to the *East Anglian Daily Times* it entered near the chimney, and passed through the upper room and struck the bell wires, severing them. Tearing away and scorching the paper, it continued its way along the wires to the second flight, and at each place where it met with any resistance it broke the wires and scorched the paper on the walls. It again passed to the lower floor by the wires, and in the downstair passage melted a gas-pipe, and then exploded like an immense quantity of crackers. The connection of the bells to every room but one was completely severed, and the wires left hanging down the walls.

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Water Power of the Rhone at Geneva.—Colonel Turrettini, the engineer of the St. Gothard Tunnel, has made a report on the works which have been carried out at Geneva under his superintendence. The left arm of the river, where the island divides it, is provided with 20 turbines, yielding 4,400 horse-power. One half of these are in use. A hydraulic service, with a head of 460ft., is supplied by pumps driven from this source. Last year there were 216 industrial motors, with a total output of 1,565 horse-power, the minimum being ⅓ horse-power for sewing machines, up to 625 horse-power for the electric light company. The total cost of the work has been £284,000. The income is said to be—for power, 2,500 horse-power for 3,000 hours at 0·08fr., 600,000fr. (£24,000); 2,500 horse-power for 5,000 hours at 0·08fr., 1,000,000fr. (£40,000). For light, 15,000 lights at 30fr., 450,000fr. (£18,000). Total income, 2,050,000fr. (£82,000). The following particulars with regard to the water-power electric lighting station at Geneva may prove of interest. The concession was granted by the town in 1887 to the Société d'Appareillage Électrique, and the station came into operatfon in February, 1888. The plant comprises three Weibel-Briquet turbines driving 2,100 horse-power Thury dynamos, and one 25 horse-power turbine driving two small Thury machines. The distribution is carried out on the Edison 3-wire system. While the concession lasts, that is to say until the end of 1895, the street lights are to be supplied at the following rates: 16 candle-power lamps at ·475d. per hour, 10 candle-power lamps at ·38d., and 8 candle-power lamps at ·285d. per hour. At the end of last year 5,000 lamps had been connected to the Company's mains, current being supplied at the rate of 5½d. the kilowatt hour. The water is supplied to the company by the town at a charge of ·19d. the cubic metre, the minimum amount to be charged for in any one year being 400,000 cubic metres (88,000,000 gallons). In 1889 1,120,000 cubic metres (246,400,000 gallons) were consumed.

The Fire Alarm System of Jersey City.—A system of fire alarms has been introduced by the fire department of Jersey City, which could be used with advantage, it would appear, in towns where there is no regularly paid force of firemen. The peculiarity of the system consists in ringing tower bells in different parts of the city by means of electric signals from alarm boxes placed as usual in conspicuous places in the public thoroughfares. In Jersey City there are four towers, from each of which every fire alarm is sounded, according to the number of the box whence it has been sent. The electric service also rings the gongs in all the fire-engine houses of the city. If a fire occurs a box is opened, a handle pulled down, an electric circuit broken, and the armature of an electro-magnet is released, starting the mechanism. A metal drum rotates under a spring that presses on it. The circuit, including the magnet, is completed through this spring. A number of notches are cut in the periphery of the drum. As it rotates, the spring drops down into these notches, and each time that it does so breaks the circuit. Each time that this occurs the bells in all the engine houses in the city ring, and the four bells in the towers ring the same alarm at a slower rate. The notches are cut differently for each box, so as to form by their combination and spacing a special signal. When a box is rung, its "makes and breaks" are transmitted to the central electric station, where they actuate an automatic recorder and repeater. By one part of this apparatus the signal is recorded by holes punched in a strip of paper or "tape," and at the same time is repeated by relay action to all the engine houses. The same apparatus by its second division regulates the current to the four bell towers. Like the other circuits, the bell-tower circuit is kept closed. The repeater, therefore, has to open the circuit once for each ring corresponding to the box number, and has also to space these properly to express the two digits that generally compose this number. It has also to perform one additional function. The signals are sent out to the engine-houses at the rate of a beat a second. This speed would not answer for the large bells, and the repeater sends out the signal at a slower rate for them. The tape is fed at speed regulated for one break per second, through that part of the apparatus which perforates it, and sends out the signals to the engine-houses. Next, the paper is fed through the part of the mechanism which operates the tower bells. The tape passes through this at one-half the former speed. A flat spring presses upon it and keeps the circuit closed as the paper holds it up in contact with a terminal. When a hole comes beneath it, its point drops into the hole, and the circuit is broken for an instant, and the bells ring once. Thus, an autographic repetition at reduced speed of the engine-house signals is given The bells are rung by mechanism actuated by a descending weight of 3,000lb. When the circuit is closed an armature is held attracted by the magnet, and the motion is arrested. When the circuit is opened, the falling away of the armature releases a detent, and the ratchet wheel holding the weight begins to revolve. The action of a lever connected to two pawls, which engage at regular intervals with the ratchet wheel as it revolves, causes a clapper to strike the bell.

Electrical Engineering College of New Jersey.—In a recent number of the *Electrical World* there appears a description of this College, which has been recently established at Princetown, and is designed to give a thorough training in both theoretical and applied electricity. The course proper extends over a period of two years, but must be preceded by a preliminary three years' course in the School of Science, or its equivalent. These first three years are essentially the same as the course in the Department of Civil Engineering, and the subjects required for admission are the same. They include the English branches; in mathematics, arithmetic entire, with the metric system, algebra, plane geometry; languages, either French or German grammar and translation. In the freshman year a great deal of attention is paid to mechanical and technical drawing. Throughout the entire course great stress is laid upon mathematics, and the work therein is very rigid. At the end of the junior year the regular student is prepared for and admitted without further examination to the Department of Electrical Engineering. The student then enters the electrical course proper, although during the first year some of the work is with the regular required senior course. It includes applied mechanics, theory of machines and prime motors, mechanism and machine drawing and strength of materials. Eight hours a week are given to the study of these subjects throughout the year, and elementary work is done in the physical laboratories during two days of the week. In the second year the theory of electrical measurements is studied, Fleming's "Alternate-Current Transformer" being the text-book employed. Advanced electrical measurements and the testing of the various machines form a part of the second-year course. Meetings are held once a week, in which the students present reports and discussions on the current electrical literature. In addition to the facilities afforded by the laboratories of the John C. Green School of Science, two buildings specially designed and constructed have been provided to meet the requirements of this course. The dynamo building is L-shaped, the boiler and engine occupying one wing of the L. It is constructed of rough ashlar brown stone with light sandstone trimmings, and makes a very pretty companion to the handsome Scientific School building. The dynamo room is 53 feet long, well lighted and ventilated. The floor is of artificial stone, flush with the heavy timbers which form the foundations, to which are bolted the bed plates of the machines. The engine belts to a countershaft at the ceiling, from which the dynamos take their power. Each belt pulley has a separate clutch, controlled by a long handle from the floor. A 60-horse Babcock and Wilcox boiler supplies steam to a 60-horse Ball tandem compound engine which furnishes power for the machines. The dynamos are of various types, including a Westinghouse alternate-current machine of 500 lights capacity, a Brush arc lighter of 18 lights capacity, an Edison of 200-light capacity, a Mather of 200, a Brush incandescent of 100, and an Eickemeyer of 50 lights; whilst a small Gramme machine charges four sets of accumulators. The dynamo room also contains a German silver rheostat, capable of absorbing 50-horse power. Some little distance from the dynamo is the magnetic observatory, which is built entirely without iron, brass and copper being used instead, even the motor used for stirring the water in the tanks in which the resistance coils are placed being constructed without iron cores.

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MAGNETISM IN IRON AND OTHER METALS.*—XXVII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 373.*)

§ 103. Apparatus for Applying the Isthmus Method.—In applying the isthmus method it is desirable to be able to turn the bobbin round suddenly between the magnet poles, in order to determine the ballistic effect produced by reversal of its magnetism. An arrangement used by the writer for this purpose is shown in Figs. 73 and 74. Fig. 73 shows the electro-magnet as a

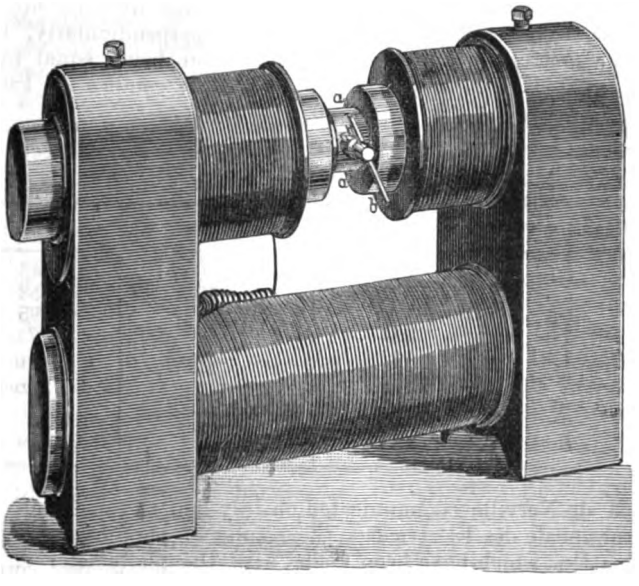

FIG. 73.—Electro-Magnet for the Isthmus Method.

whole, and Fig. 74 is a sectional sketch of the pole-pieces and bobbin and bobbin-holder. The poles, which are four inches in diameter, admit of having the distance between them adjusted,

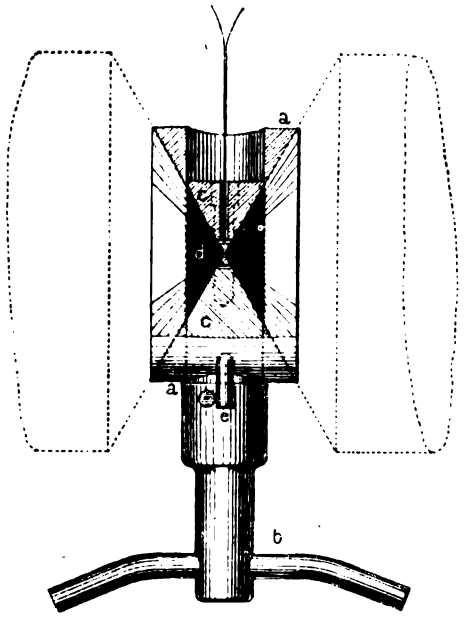

FIG. 74.—Section through bobbin and bobbin-holder.

and a brass piece *a a* is fitted between them, having hollow cones turned out of its ends, into which the conical pole-pieces fit exactly. This holds the pole-pieces at the proper distance apart. Through the brass piece, *a a*, a cylindrical hole is bored, extending through from side to side, and removing the points of the conical pole-pieces. Into this hole the bobbin-holder, *c c*, with the bobbin, *d*, is slipped from one side. The part which projects outside of *a* has a shoulder turned on it, which, when it is pressed home, brings the axis of the bobbin just into line with the axis of the pole-pieces. The bobbin-holder is of brass, and is made of two pieces, *c c*, between which the bobbin *d* is clutched, the pieces being fastened together by long screws put in from the end of the holder, which pass clear of the bobbin on each side of the neck. There is a little clearance round the neck to give room for the induction coils to be wound, and the leading wires from these pass out through a hole in the end of the holder. The bobbin *d* has its ends turned so that they virtually form part of the cylindrical surface of the holder, and it fits exactly into the cylindrical hole between the pole-piece ends. The handle *b* attached to the holder allows the bobbin to be suddenly reversed, and a stop is provided at *e* to make the movement exactly 180°. The electro-magnet of Fig. 73 is furnished with two pairs of conical pole-pieces, one pair sloped to give maximum concentrative power (§ 95) and the other pair to give maximum uniformity in the field (§ 97). For each pair a bobbin of the iron or other metal to be tested, is turned with the same slope, and for each pair there is a distance-piece and bobbin-holder to correspond.

§ 104. Experiments by Du Bois with Strong Fields. Optical Method.—The conclusions which were arrived at by means of the isthmus method, as to the existence of a finite limit to the intensity of magnetism, and as to the manner in which that limit is approached when strong magnetic forces are applied, have received independent confirmation from the later experiments by H. E. J. G. du Bois*, in which a novel and highly interesting method of measurement was introduced and used with excellent effect. The method is an optical one, based on Dr. Kerr's discovery,† that when plane polarised light is reflected by a magnet pole the plane of polarisation is turned, through an angle which depends on the intensity of the magnetisation. Before this fact could be turned to account for the purpose of measuring magnetism, it was necessary to know exactly what relation holds between the magnetism of the reflecting metal and the angle of rotation of the polarised ray. This question was made the subject of a preliminary investigation by Du Bois,‡ who answered it by examining the rotation of the ray when reflected from small surfaces, ground flat, and polished, on ellipsoids of iron, steel, nickel, and cobalt, the ellipsoids being magnetised by means of a surrounding coil. He found that the relation is of a very simple kind: the rotation of the polarised ray is proportional to the intensity of magnetism **I**, and may, therefore, be written equal to K **I** when K is a constant§ coefficient, to which Du Bois gave the name of Kerr's constant. He determined numerical values of K for iron, steel, nickel, and cobalt. Knowing these, it is, of course, possible to invert the process, and use the measurements of optical rotation to determine values of **I** in cases where they are not otherwise known.

This Du Bois has done in a way that will be readily understood by reference to Fig. 75 (taken from his second Paper). P_1 P_2 are the poles of a powerful electro-magnet, made conical, as in the isthmus method, for the purpose of concentrating magnetic force in the neighbourhood of the apex. Through one of them (P_2) a hole is bored to allow the polarised light to come to, and, after reflexion, to return from, the polished plate M, which is a small piece of the metal whose magnetism is to be examined, and is in contact with the magnet pole P_1. When the electro-magnet is excited, M is very strongly magnetised, and the value of **I** in it is measured by observing the angle of rotation of the polarised ray and dividing that by the known value of Kerr's constant, previously determined by experiments with a magnetised ellipsoid of the same material. J J is a steam jacket which was used to maintain the plate at a temperature approaching 100° C in some of the experiments.

We have said nothing yet about the manner of finding the magnetic force **H** acting on the plate M. It was not found directly; what was directly found was the induction **B**. When **I** and **B** are known, **H** may of course be deduced by means of

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* Du Bois, *Phil. Mag.*, April, 1890, p. 293.
† Kerr, Brit. Ass. *Report*, 1876, p. 40; *Phil. Mag.*, May, 1877, p. 321.
‡ *Phil. Mag.*, March, 1890, p. 263.
§ Constant, that is to say, for any one metal, and for any one wave-length of light. K differs much for light of different wave-lengths.

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the equation $H = B - 4\pi I$. Now, in determining B in the plate, it is to be borne in mind that there is no discontinuity in lines of induction. The lines of induction here pass out of the plate normal to its surface, and B within the plate has the same value as the induction (or what is there the same thing, the magnetic force) in the air immediately in front of the plate. This fact was taken advantage of in determining B. It might have been measured ballistically by slipping out an induction coil laid on the face of M, or wound round the circumference of M; but the plan actually used by Du Bois was an optical one. A thin glass plate G, with a silvered back S, could be interposed in the path of the ray, immediately in front of the plate M—that is to say, at the place where a determination of the magnetic field was wanted. A plane polarised ray passing through a plate of glass in a magnetic field suffers rotation, as Faraday originally showed, and the amount of this rotation is proportional to the magnetic force and to the thickness of the plate. In the present case the ray passed twice through the glass plate. The plate was standardised by comparing the magneto-optic rotation in it with that in bisulphide of carbon, the value of which is well known. Thus, by means of two independent optical measurements, there were determined, first, the value of I in the strongly magnetised plate M of iron or other magnetic metal (by observing the rotation of a polarised ray reflected

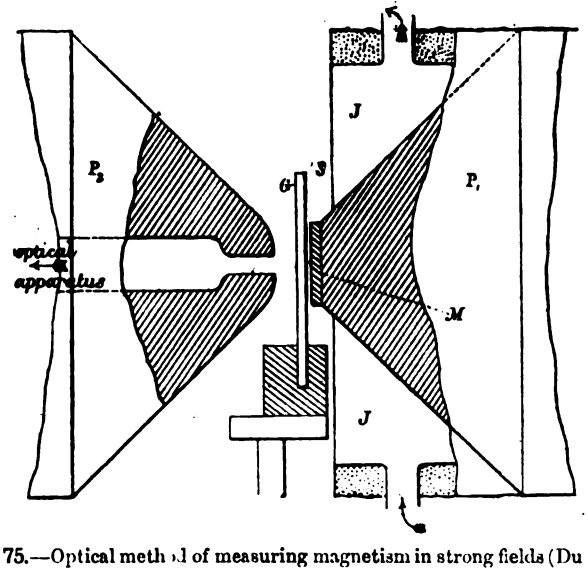

FIG. 75.—Optical method of measuring magnetism in strong fields (Du Bois).

by M), and, second, the value of B in the same plate, this last being equal to the magnetic force acting on the glass plate when the glass plate was put in front of the other, and being measured by observing the rotation of a polarised ray reflected from the silvered back of the glass.

(To be continued.)

MEASUREMENTS OF ILLUMINATION.

While the history of photometry dates from the work of Count Rumford at the commencement of this century, and has been carried to as great perfection as the power of comparing lights by the eye of a skilled observer will allow, no attempt appears to have been made until recently to measure illumination; that is to say, the degree of brilliance or luminosity in any locality produced by any arrangement of artificial lights or by daylight. A unit of illumination may be conveniently expressed in terms of a length and of a unit of light, being the illumination produced by unit light at unit distance. Mr. Preece pointed out at the beginning of 1884 that a carcel-metre is equivalent to a British standard candle at 12·7in.; and the name "lux" was suggested for it. The name has not been used, if for no other reason than that measurements of illumination have very seldom been made. M. de Nerville, director of the Central Laboratory of Electricity, has recently made a number of such observations in Paris. He has employed as a unit a bougie-metre, the bougie being a "*bougie décimale*," the tenth of a carcel burning 42 grammes of oil per hour. This is equivalent to a standard candle at 3·34ft. distance, which is a more convenient expression than one-tenth of a candle at 12·7in. The ·7in. cannot be neglected, since it amounts to a difference of about 12 per cent., a quantity which can be easily distinguished, and a greater difference than between yards and metres. The bougie-metre is a unit of very convenient magnitude. It is the same as the deci-lux of Mr. Preece, and is practically the illumination at the foot of an ordinary gas street-lamp, say 13 candles at 12ft.

The relations of the candle-power and the distance are, of course, very simple for light falling perpendicularly, the bougie-metre or deci-lux unit illumination being equal to 1 candle at 12·7 inches, or 1·058 foot, or n candles at 1·058 $\times \sqrt{n}$ feet, as shown in the following table:—

Bougie-metres.

Candle-power.	Feet.	Candle-power.	Feet.
0·1	1·058	8	9·45
0·5	2·37	10	10·58
0·8	3·0	20	14·95
1·0	3·34	50	23·7
1·5	4·1	100	33·4
2	4·73	200	47·3
3	5·8	500	74·8
4	6·69	1,000	105·8
5	7·48	2,000	149·5

M. de Nerville communicated on July 2nd to the Société Internationale des Électriciens the results of photometric determinations which have been made with the photometer of M. Mascart at the Opera, the Hippodrome, in the salons of the Hôtel Continental, at the Central Post Office and at the Halles Centrales at Paris. He refers to several general observations which he had communicated at a previous meeting on similar measurements made at the Exhibition. Tables are given showing the results obtained. They are expressed in bougies-metres. The screen of the photometer was 1m. 50 (4ft. 11in.) above the ground. Red and green glasses were used, and the readings of both are given.

At the Opera House, where the first series was taken, the auditorium has 450 Edison lamps of 10 candle-power, and 144 of 16 candle-power. Thirteen measurements were made in various parts of the house, with the screen of the photometer pointing in different directions, which are described in full in M. de Nerville's Paper. We find the average to be 10 bougies-metres for the red, and 9 for the green glass. Again, in the *grand foyer*, there were 524 ten-candle lamps. The average of seven measurements was 12 bougies-metres; or, omitting two sets taken under the arcade, 14 bougies-metres, the figures for the red and for the green being almost identical.

Two sets of measurements of the illumination of the Hippodrome were taken. There were 20 Jablochkoff candles of 4mm. in thick opal globes; 16 Gramme arcs of 25 amperes, in clear globes; 3 Gramme arcs of 45 amperes, and 8 Brockie-Pell of 12 amperes. Full details of each measurement are given, but, taking the average of six sets, we find that the red gave 44, and the green 70 bougies-metres respectively. The ratio of green to red for the glow lamps was unity in one case, and 9 to 10 in another; but for the arc lighting it is 7 to 4 or 1·75 to 1, showing the larger proportion of red and yellow rays from the glow lamps. The Petit Salle des Hommes of the Central Post Office is lit by 13 Cance lamps of 8 amperes. The red gives an average of 13, and the green 18 bougie-metres—a much larger proportion of red than in the larger arcs at the Hippodrome. One of the other rooms was lit with gas, with Cromartie burners, and gave an average of 9 with the red and 10 with the green, being a whiter light than that of the Edison lamp at the Opera House.

To compare artificial lights with daylight, several measurements were made at different times of the year, and in different states of the weather. The highest reading given is 1,110

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bougies-metres with the green glass, and 3·26 with the red, giving a ratio of nearly 3 to 1. This was observed at four o'clock in the afternoon of May 1, 1890. The windows of the room in which the measurements were made were provided with white blinds, and in this case the sun was shining directly on them. On the same day a reading of 740 with the green, and 228 with the red glass was taken at 10:30 in the morning, the window not being directly facing the sun. The ratio here is 3·24 to 1. At five p.m. on the same day the ratio was 3·44, but the total illumination was about one-half of that of the morning observation. It may be assumed, then, that for pure white light, of which the sun is our standard, the ratio of the glasses in this particular photometer is about 3·5 to 1. The arc lighting at the Hippodrome, where the ratio was 1·75 to 1, therefore has a double proportion of red and yellow rays, compared with a pure white light, while the glow lamps and gas have 2·85 times the proper quantity of red light.

A reading was taken with the photometer turned towards the full moon, and the value was found to be about one-third of a bougie-metre. We have found it to be from one-seventh to one-fifth of this unit on clear nights, and are inclined to think that M. de Nerville's reading is rather high.

For interior lighting the production of illumination is almost invariably the only object of artificial lights, but out of doors it is otherwise. A lighthouse, for example, is not intended to illuminate a surface, but merely to be seen as a brilliant image. Other signal lights on railways and on carriages are intended chiefly to act as beacons, though a good carriage-lamp illuminates the road as well. Street lighting must be considered from both points of view. The mere illumination produced by the full moon, say one-fifth of a bougie-metre, would be sufficient for most purposes in the streets if this could be carried out uniformly by any artificial means, but street lamps act also as beacons. Even an arc lamp of 1,000 candle-power produces very little actual illumination at a distance of 150ft., say one-half of a bougie-metre on a surface turned to face towards it; but such a lamp would be very useful in a street as a beacon. The lighting of Cheapside, in 1884, by Brush lamps was of this character. The lamps, with the globes in their ordinary condition, gave about 400 to 500 candle-power. At the foot of each post, which was about 15ft. high, the illumination would have been 20 bougie-metres had there been no shadow. Midway between two lamps, the illumination on the ground was less than half a bougie-metre.

M. de Nerville does not give the averages of his measurements nor the ratios of the red to the green. The average of all the observations made in one locality does not give the true mean illumination of the place; but for the present purpose this is sufficient. He does not state how the readings with the red and the green glasses are to be dealt with; and it is generally acknowledged by the few who have taken any interest in the matter, that neither the sum nor the mean of the two is a measure of the total illumination.

In the large majority of cases, light is appreciated merely in so far as it causes the subjective effect of vision, and subjective effects on different individuals cannot readily be compared. One person may prefer an ample quantity of yellowish light, while another is equally satisfied with less, if it be of a whiter colour. The general public who need electric light are composed of both of these classes; and it is therefore useless to compare an illumination, say at the Paris Hippodrome, and to attempt to calculate the exact proportion between it and full sunlight, or ordinary daylight.

Electric and Thermal Conductivities.—In a recent number of the *Comptes Rendus* is a Paper "On the Ratio between the Electric and Thermal Conductivities of Metals," by A. Berget. The author has determined in absolute measure the electric conductivity k, and the thermal conductivity c, of copper, zinc, iron, tin, lead, antimony, mercury, and brass, at temperatures between 0deg. and 30deg. The ratio $k \div c$ varies from $1{\cdot}6 \times 10^3$ to $1{\cdot}8 \times 10^3$. The temperature co-efficient of the two conductivities is also different. Hence they can only be regarded as approximately proportional to one another.

ELECTRICAL FORGING AND CASE-HARDENING.

Two new developments of the electric welding process have been made, which indicate that there may be many other applications for working metal by electrical heating. In one of these, devised by Mr. Lemp, of the Thomson Welding Company, the ends of two bars are brought to a bright forging heat in a modified form of welding machine, but they are only in contact for a sufficient time and with the necessary pressure to allow the heat to be produced. They are separated, the current is shut off, and a die of any desired shape is introduced between them. They are then forcibly brought towards each other by a steam cylinder and piston, which presses the heated ends into the dies, and allows any required shape to be given to them. In this manner letter punches may be easily forged. Prof. Elihu Thomson has experimented also on the protection of the work during the operations of welding or forging from the oxidising action of the air. For this purpose a casing or chamber is constructed of sheet-iron in two parts hinged together and provided with insulating packing of mica or asbestos at points where the bars which are being heated are clasped. A current of hydrogen or nitrogen is passed through the chamber, thus displacing the air and preventing oxidation. A further development of this idea is the use of a hydro-carbon gas or vapour, by which "flashing" on a large scale is carried on, and a layer of carbon is deposited on the metal. When iron is used the carbon thus deposited carbonises the surface, which becomes steeled or case-hardened. From the brief account given in the *Electrical Engineer* of New York we cannot ascertain whether this method has passed beyond the experimental stage; and it appears to us doubtful whether the process could be carried out economically, since it must require time, and even if water-power or other cheap form of energy were used it would not pay to employ such expensive tools as welding machines and the powerful dynamos which are their necessary adjuncts for any prolonged work. Little is known of the diffusion of carbon in steel. The old process of cementation for making blister steel required some six or eight days for the carburation of three-quarter inch bars, and this was followed by ten days or a fortnight for cooling. It does not seem likely that the deposition of carbon in a nascent state would hasten the process. Of course the idea is only intended for superficial case-hardening. The new process can only be valuable if it will case-harden as deeply as the modified cementation carried out by makers of high-class machinery under the name of deep case-hardening.

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(1) ON THE DISCHARGE OF ELECTRICITY THROUGH GASES; (2) ON THE FALL OF POTENTIAL.*

BY A. HEYDWEILLER.

Sir William Thomson first observed that the difference of potential necessary to cause the passage of an electric spark through a gas (air) between very close, smooth electrodes, is not proportional to the distance between them, but increases more slowly than this distance. Maxwell gives two explanatory notes on this point. The author wishes to corroborate that one which states that this may be due to a condensation of the air at the surface of the conductors, so as to produce better insulation, the two condensed strata being brought up to one another when the two electrodes are very close. A further question is as to what is the result in a non-homogeneous medium, as, for instance, between the surfaces of concentric cylinders, or two spheres external to one another. In the numerous experiments made on this point, no attention has hitherto been paid to the fact that the greatest and least values of the fall in potential at discharge are easily calculated from the size and distance of the electrodes and from the residual potential. This calculation shows also that the maximum tension is not nearly the same in all cases; but the mean (so called, absolute) values of the fall of potential taking place at discharge at the two electrodes in all cases with increasing distance, shows an analogy with that taking place in homogeneous fields. The limiting value of the fall of potential increases with increasing curvature of the electrodes.

The conclusions to which the author arrrives are:—

(1) It is possible to explain the peculiarity of fall of potential on a spark passing through air between smooth electrodes, on the sup-

* *Wiedm. Ann.*, Bd. 40, Heft. 7.

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position of air being absorbed on the electrodes; but they must be larger than this layer of condensed air; further it decreases with increased curvature.

(2) The mean fall (*i.e.*, the arithmetical mean of the differences at both electrodes) is, in non-homogeneous, as in homogeneous, fields independent of the distance.

(3) The mean fall increases with increased curvature.

(4) From this mean fall, the maximum charge of a sphere in air may be calculated.

ON UNITS OF LIGHT AND BRIGHTNESS.*

BY PROF. DR. LEONHARD WEBER, BRESLAU.

Unit of superficial brightness: Important, but neglected. Suppose a luminous point be the source of light, the intensity of which is I, say, so many candles; then at the distance, d, the *quantity* of light which falls on a surface (at right angles to the rays of light), the superficial area of which is a, may be represented by $q = Ia/d^2$. But if we take into account the superficial brightness, or brilliancy, of the source of light, we must substitute for the term I, or intensity of the source of light, another term—namely, A·B., or the product of the *area* and the *brilliancy* of the source. Similarly, we may consider the brilliancy of illumination of the area illuminated; and this brilliancy (which we may represent by b) is found by dividing the quantity of light falling on the whole of that area by the area itself; that is, $b = q/a$. Thus we have three simple algebraic equations connecting the terms of our statements: these being (1) $q = Ia/d^2$; (2) $I = A \cdot B$; (3) $b = q/a$. To use these equations it will be necessary to fix our units of reckoning. Suppose we use, as the unit of bright or illuminated area, the square centimetre, and as the unit of distance the metre, then the second equation shows that the brilliancy B of an extended source of light is unity when it gives as much light per square centimetre (off its own area) as a luminous point of unit intensity would give at the same distance; and by combining equations (1) and (3) above we get the equation $b = I/d^2$, which means that the brightness of the illuminated surface is unity when it gets as much light from the source as it would have got from a unit source of light at one metre distance; this being the basis of measuring illumination, as distinguished from light, in "metre candles" (or "foot candles"). If we start from a unit of brilliancy instead of a unit of intensity we will arrive at corresponding values, but in every case we must distinguish between the actual intensity of a source of light, or quantity of light, falling on an illuminated area on the one hand, and the brilliancy of the source, or brilliancy of illumination, on the other. Now, the great difference between the platinum unit and the candle is that the latter is a standard of actual intensity only; while the former, since it defines the area of the source, is a standard both of intensity and of brilliancy. The amyl-acetate lamp gives a flame of about 2·27 sq. cm. in effective area; so that its actual lighting power being so-and-so in platinum units, its brilliancy will be less in the ratio of 2·27 to 1.

The range of brightness or brilliancy is extreme. A sheet of printed paper which we can just read is some thousand millionfold less bright an object than the sun at noonday; but the estimation of brightness is a matter of increasing importance, both with regard to the source of light and to illuminated objects; and the use of a standard of brightness will help to make clear our comparisons. From this point of view, the actual light from a platinum unit being about 20 times that of an amyl-acetate lamp-flame, and the area of that flame being 2·27 sq. cm., the brightness of the platinum may, if we please, be represented as 20 in amyl-acetate units, and that of the flame itself as 0·4. On the same basis the brightness of the sun is about 160,000, that of the sky 0·1 to 1, that of a printed paper which we can barely read 0·00006, and that of a barely visible surface 0·0000001.

A convenient subsidiary unit of comparison is the brightness of a piece of white paper at a distance of one metre from a unit source of light, and itself serving as a source of light, the brilliancy of which may be taken as a standard. But perfectly white matt surfaces cannot be obtained, and only approximate results could be reached in this way. It might also be of great advantage to use multiples of the unit of brightness, micro- and macro-units, as is now done with other units of measurement.

If the amyl-acetate lamp be adhered to, it might be used as a unit standard of brightness by taking only one sq. cm. of the flame; then other flames would be equally bright if one sq. cm. emitted the same quantity of light, and so on in proportion.

The following data, partly obtained in the laboratory here, and partly due to Dr. Michalke, Trebnitz, will illustrate this matter.

For red light (wave-length = 640 ten millionths of a centimetre) 1 pt. unit = 15·75 amyl-flames; for green light (w.-l. = 541) 1 pt. unit = 20·4 amyl-flames. Sperm-candle = 1·12 amyl-flame (Weber): 1·17 (Liebenthal). Violle makes the pt. unit equal in respect of white light to 18·5 sperm candles; whence it would be equal to 20·7 amyl-flames (Weber) or 21·6 (Liebenthal): [its *brightness* will therefore be to that of the amyl-acetate lamp flame in the ratio of 20·7 to 0·4, or 83 to 1].

Table of Relative Brightness.

—	Through red glass.	Through green glass.
Platinum, incandescent just before melting	1	1
Sun's disc	4092	8417
Sky near the sun's disc	1*	1*
Albo-carbon burner, edge on	0·615*	0·509*
White paper, bright summer (Breslau, June 12, 1885, 12 noon), horizontal, exposed to whole sky	0·138	0·295
White paper, sun 60° high, paper facing towards sun	0·069	0·144
White clouds, shone upon by sun	0·021	0·089
Albo-carbon burner, face on	0·088*	0·073*
Argand burner	0·057	0·044
Clear sky at right angles to sun, sun being 60° above horizon	0·008	0·05
White paper on a dark winter's day lit by whole sky (Breslau, December 22, 1884, noon)	0·0010	0·0030
Black velvet, bright summer day (Breslau, June 12, 1885, 12 noon), exposed to whole sky	0·00028	0·00059
White paper, reading without straining	0·000015	0·000020

* About.

A SUGGESTED ALTERNATOR.

We illustrate below a form of alternator, suggested more than three years ago by Mr. Mordey, which is of interest as showing an exceedingly simple form of machine, and as embodying the principle underlying a design from America, which is the latest "American novelty," and which we also illustrate this week.

The principle of the machine is shown by Fig. 1, which is a longitudinal section, and by Fig. 2, which is a partial end elevation.

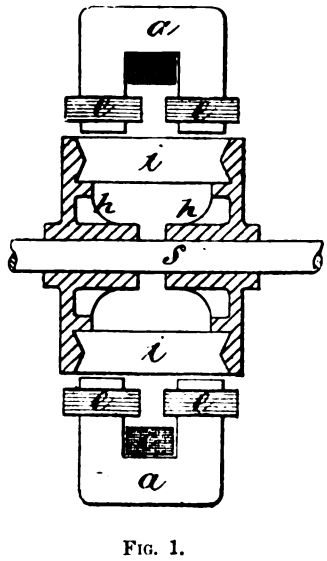

FIG. 1.

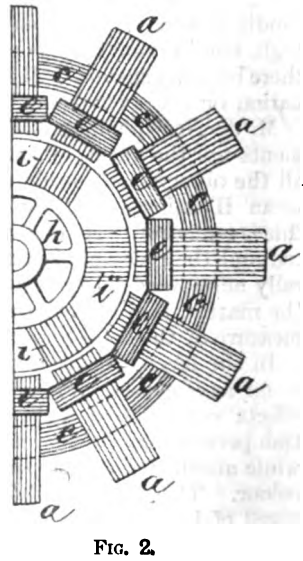

FIG. 2.

Diagram of alternating current dynamo, with rotating keeper, from Mr Mordey's Specification No. 8,262, 1887.

The machine is of the "rotating keeper" type. That is, a part of the magnetic circuit is rotated, giving rise to the generation of electromotive forces in conductors wound on other parts of the magnetic circuit.

The rotating parts are laminated iron blocks, $i\,i$, carried by means of the hubs, $h\,h$, on the shaft s. Coils $e\,e$, forming the stationary armature, are slipped over the ends of laminated U-pieces, $a\,a$, and between the legs of these U-pieces the stationary magnetising coil, $c\,c$, is wound. The action is very simple. As the "keepers" $i\,i$ are rotated the magnetisation of the U-pieces $a\,a$ rises and falls, thus setting up alternating E.M.F.s in the coils $e\,e$. It need scarcely be pointed out that the functions of the two windings may be reversed, $c\,c$ being made the armature, and $e\,e$ the field winding.

* From the *Journal für Gasbeleuchtung*, abridged.

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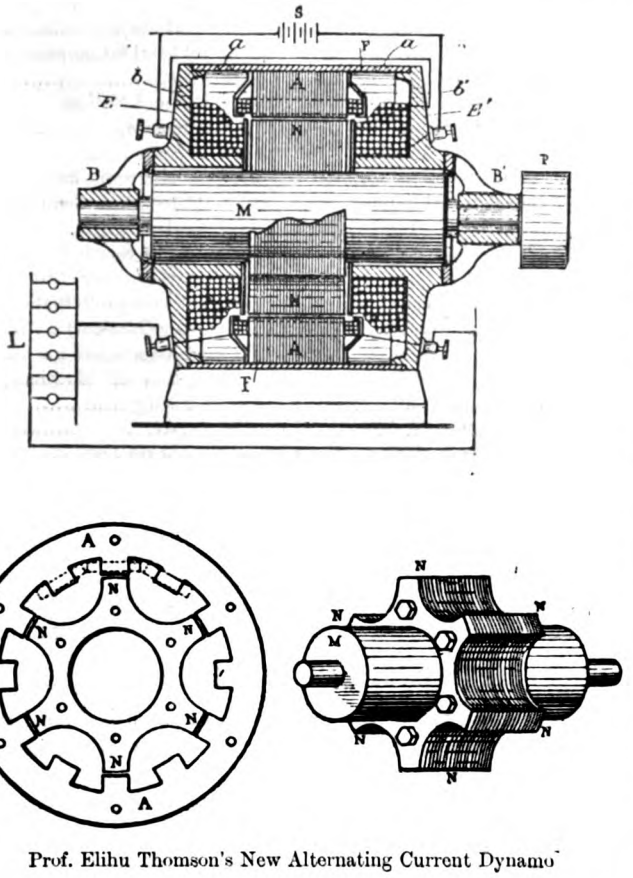
PROF. ELIHU THOMSON'S NEW ALTERNATING MACHINE.*

With the high speeds now generally employed in alternating current machines the moving coils are more or less liable to derangement, so that they are subject to both mechanical as well as electrical strain. In order to overcome this difficulty and to obtain a compact as well as efficient machine, Prof. Elihu Thomson has recently constructed an alternator in which all the coils are stationary, and so that no moving contacts whatever are necessary to conduct the current from machine to line. The machine is shown in section in the accompanying illustration, and consists of a stationary armature A, within which revolves the field-magnet.

The armature A is built up of a number of ring-shaped plates or sections of rings bolted together to form practically a compound laminated ring. It corresponds in a measure to a fixed laminated armature, and is supported in the interior of the outside casing.

The end plates E E′ are joined at their outer portions by the iron frame-work or casing F, consisting of a cylinder surrounding the machine. It is designed to connect the outer edges of the end plates E E′ magnetically with the stationary laminated ring A, surrounding the core M so as to embrace the centrally projecting



Prof. Elihu Thomson's New Alternating Current Dynamo

portions of the core M. To the inner side of the structure A, and upon projections extending radially inward, are applied the coils, the ring and coils thus resembling a multipolar ring or cylindrical-shaped magnet whose poles are on the inside.

The field-magnet coils are supported fixedly in the casing, and energise the multipolar field magnet M, all the poles of which are of like name, as shown at N N, &c. The core M is fixed to the shaft of the machine, and has the laminated pole-pieces keyed to it.

The ring structure A A has interior projections of double the number of the projecting poles N N N, carried by the ring core piece. On these projections are firmly secured the coils in which currents are to be induced, and which are connected to the line wires. The field-magnets, of course, require to be energised by a continuous current, which can be furnished by a separate exciting machine.

The action of the machine is as follows :—The moving field-poles N N N, &c., carried around on the revolution of the core-piece M, pass in front of the coils in which the currents are to be induced. The lines of magnetic force projecting from these pole-pieces cut across the wire on the coils transversely. The direction of the winding and the connection is such as to make the effects cumulative in the coils—that is, so that if a polar projection N passes over the centre of one coil to that of the next, shown in the lower figure, its lines are caused to cut the wire lying between those centres, half of which would belong to that coil the centre of which is being left by the travelling pole, and half to the coil toward the centre of which the travelling pole is moving.

These actions of induction repeatedly following one another will be accomplished without a reversal of magnetism in the core-piece, or even in the laminated ring structure supporting the coils in which the currents are induced ; but, on the contrary, the lines of force will simply be carried rapidly past wires, whose virtual direction of winding is opposite alternately, and this will generate impulses without the necessity of magnetic changes of polarity taking place in any of the core-pieces. Prof. Thomson is thus enabled to save a large portion of the loss due to magnetic changes or "hysteresis" in the iron of the machine, while still utilising the iron to the best advantage in the construction of the magnetic masses subject to the magnetising actions of the field coils. A strong magnetic field is also secured by the expenditure of a minimum of energy for sustaining the same ; and, besides this, none of the wire in the machine need revolve, thus dispensing altogether with rubbing surfaces or sliding contacts when the machine is used for the generation of alternating currents.

* From the *Electrical Engineer* of New York.

THE ROVELLO ELECTROLYTIC PROCESS FOR EXTRACTING COPPER.*

The cupriferous water obtained in the process of roasting copper pyrites in the manufacture of sulphuric acid is usually treated with iron filings, which precipitate the copper in the condition of an impure mass containing about 75 per cent. of copper, which it is necessary afterwards to compress, dry, melt, and refine. The object of M. Rovello's process is to electrolyse this cupriferous water in such a manner as to precipitate the copper in such a form as to render it immediately useful. His apparatus consists essentially of a large Daniell battery, the electro-negative elements of which are of sheet or cast-iron, instead of zinc, and are separated from the copper plates by porous partitions. The electro-motive force of an element of this kind (iron-copper) being about ·6 volts, a current of 200 amperes should be obtained with a battery of an internal resistance of ·003 ohms, capable of precipitating (at the rate of 1·19 grammes per ampere hour) 6 kilogrammes (13lbs.) of copper per hour. In order to lower the internal resistance to ·003 ohms, it is necessary to use electrodes with large surfaces and diaphragms of very low specific resistance. The electrolytic batteries are built up of a series of wooden frames separating the cathodes from the anodes by membranes of parchment. The anodes and cathodes are respectively fastened together by bars of copper. The frames and parchments are pierced by four holes, in which are inserted four tubes. Two of these tubes communicate with the even elements and a funnel, and the other two with the odd elements and a second funnel. The cupriferous liquid is poured in in a narrow stream and passes through into the cathode compartments, and the solution of sulphate of iron is poured into the anode compartments. These liquids escape separately by the overflow pipes. The weakened solution of sulphate of copper may afterwards be completely exhausted in a second apparatus. The operation is carried on without help from any source of electricity other than the baths themselves, which are short-circuited.

* From *La Lumière Électrique*.

BOOKS, &c., RECEIVED.

"Revista de la Union Militar." (Buenos Aires: Establecimiento de Impressiones de Guillermo Kraft.)

"The Gas and Water Companies' Directory." (London: Messrs. Hazell, Watson, and Viney.)

"Brown's Directory of American Gas Companies." (New York: "Progressive Age" Press.")

"Dictionnaire d'Électricité et de Magnétisme." (Paris: J. B. Baillière et Fils.)

"Tourist Guide to the Continent. Walks in the Ardennes." (London : Published for the Great Eastern Railway Company, 125, Fleet-street.)

"First Steps in Spanish Idioms and First Spanish Book." (London : Hachette and Co.)

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INVENTION AS A PROFESSION.

In these days, when each profession draws a jealous line of demarcation between itself and its neighbour, it may be interesting to inquire whether invention can be looked on as a legitimate profession. Can a man with a fair amount of ingenuity and originality expect to make a moderate income by devoting his talents to enlarging the sphere of mechanics, physics, or any of their subordinate branches? Can he after embarking on this line of life look forward to a reasonable amount of support from his fellow-labourers in keeping up the price of the wares they vend and insuring to the inventor a reasonable return for his labour?

There is a well-founded belief that the prospects of the inventor can never be quite so rosy as that of the man who succeeds in other professions. The invention doubtless may supply a long-felt want and may be of incalculable service to society; but the proceeds too often line the pockets, not of the needy inventor, but of the manufacturer who produces the article. "It is one thing," writes THACKERAY, "to write a novel, but quite another to get paid for it." So it is with inventions. It is when the preliminary work of inventing and patenting is over that the greater difficulties arise, and an opportunity is given of displaying a rarer genius in pushing the article in question and getting paid for it.

In treating of inventors as a class, however, we must carefully distinguish between discovery and invention. The

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former term is generally applied to the pioneer who extends the boundaries of a science by bringing the observations of his predecessors under new laws, by introducing a new system of classification, by discovering a new substance or a new planet. Invention, on the other hand, seems more particularly to denote a new and ingenious mechanical arrangement or a more economical method of applying force. It is obvious that of these two divisions the latter is the most profitable; a great discovery, though of immense value to the intellectual world, may very possibly be of not the slightest immediate advantage to mankind, while the inventor through whose skill the cost of production has been reduced, appeals with greater force to the spirit of the practical man. Among the ancients, it is true, and more particularly among the Greeks, greater value was attached to discoveries of a purely intellectual character. It is related of THALES, who was the first person who inscribed a right-angled triangle in a circle, that on the performance of this feat he sacrificed a bull. We must not, however, be too ready to accept this as a sign of the wealth attained to by the men of science of that day, for it does not follow that because THALES performed the sacrifice the bull was necessarily his; and, if it was, it may have been the fruit of the more practical side of this versatile genius, who, besides being a mathematician, was a civil engineer. But to confine ourselves to inventions, we find that the most striking advances have often been made by practical men who by gradual improvements on the machine of which perhaps they have been in charge, have arrived at some completely novel method of performing the same process. Probably these very men would have been totally at a loss if asked to explain the process by which they travelled from the known to the unknown, having indeed made this instinctive leap in the dark and having been led to success by the fortunate co-operation of circumstances. This may account for the extraordinary manner in which the ancients advanced to a certain point but seemed unable to get any further. The classic philosophers knew in a vague way that sound spreads like waves, and PYTHAGORAS actually measured the relation between the length of a harp-string and its notes; but any real progress in the science of acoustics dates from yesterday. A rock crystal lens has been dug up at Nineveh, and the Arab astronomers had a considerable acquaintance with optics; yet ROGER BACON, who in the thirteenth century gave an intelligent account of their science, never seems to have conceived the idea of combining two lenses into a telescope; nor was it till the seventeenth century that GALILEO heard of one which had been constructed in Holland, and on which he afterwards improved. The loadstone seems to have been first used by the Chinese magicians, whom it assisted largely in determining the aspect of the heavens; while from the earliest times rubbing a bit of amber was a favourite experiment. Yet before the time of GILBERT no attempt had been made to treat the phenomena of electricity in a scientific spirit; and the further developments connected with the names of VOLTA, GALVANI, and OERSTED seem to us incredibly slow.

There can be little doubt that the rapidly increasing differentiation between theory and practice is a great hindrance to any great progress in the spirit of invention. True, the practical side is, on the whole, the most important, but it must be conducted in the right spirit; and even BACON, the great apostle of experience, confesses that the notions derived from "a few narrow and obscure experiments" are useless, since experience to be of any use must be conducted on a scale and in a manner only attainable by the man of science. "And therefore," he continues, "to those who daily converse in such experiments, and have thereby corrupted their fancy, this philosophy seems probable and certain, but to others incredible and vain; a notable example whereof we find in the chemists and their opinions, but now scarcely anywhere else, except in Gilbert's philosophy." It seems strange that BACON should have so little appreciated the merits of the founder of electrical science; but GILBERT probably annoyed him by his tendency—a tendency in which he has been frequently imitated—to reduce to electrical phenomena all the varied phases of the universe. But though it is undeniably true that most of the inventions which have facilitated production have been made by practical men connected with the industry in question, it is no less the fact that individuals are to be found who invent for the sake of inventing. Such men seem to have a surplus stock of mechanical ingenuity which they insist on utilising, either profitably or unprofitably. If they possess the requisite amount of scientific training their talents may be turned to good acount; but too often they go to swell the ranks of makers of rotatory engines which nobody wants, tramcar starters which nobody will use, and the mechanical fanatics of every description with which the Patent Office is only too familiar. The labour of these men, however, though too often unprofitable to themselves, is, when directed to useful channels, frequently of great service to the community. It is to them that we owe the thousand little mechanical contrivances that we use in everyday life; and to these men invention, being their one absorbing pursuit, is indeed a profession. In that somewhat disappointing work of BECKMANN on the "History of Inventions" we find an account of one HOHLFIELD, born in 1711, who seems to have been an inventor of this class. As he was an excellent workman and had invented several machines for shortening his labour, he found sufficient time to indulge his inclination for mechanics, and while pursuing his usual trade—that of a lacemaker—he made air-guns and clocks. He soon had opportunities of displaying his talents in the service of SULZER, and afterwards in that of a Prussian Minister. He showed the true spirit in turning his attention to other things than improvements in lacemaking. "Every machine that this singular man saw he altered and improved in the simplest manner. It is worthy of remark that he never bestowed study upon anything; but when he had once conceived an idea he immediately executed it. He comprehended in a moment whatever was proposed, and at the same time saw how it was to be accomplished. He could therefore tell in an instant whether a thing was practicable; if he thought it was not no persuasion or offer of money could induce him to attempt it." Such is the stuff of which the true inventor is made.

But if invention is a profession it still remains a question whether it is a profitable or, indeed, a noble one. To this question no very decisive answer can be given; so much depends on the invention, the inventor, and the circumstances. But it is worthy of note that to the account of HOHLFIELD, quoted above, our author naïvely adds these words: "He had a good heart." It is much to be feared that the combination of "a good heart" with the heaven-sent spark of genius necessary to the inventor is not likely to produce the article known as the "sound man of business;" and though ARISTOTLE was, we believe, the first person to remark that money-making was an art in itself, and only accidentally conjoined to other arts, we are afraid that the inventor must in all ages have painfully experienced the truth of the maxim. It is, after all, only the old story: the scientific pioneer and the man of genius have seldom, if ever, received an adequate return for their pains; but if, as is often the case, their best work is the result of an inspiration, they have, perhaps, little cause for complaint if their sole reward often takes the abstract form of fame.

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REVIEWS.

"Electric Transmission of Energy." By GISBERT KAPP, C.E. Second edition. (London: Whittaker and Co., 2, White Hart-street.)

We are glad to notice a second edition of Mr. Kapp's very useful treatise on the electric transmission of energy. The author has been thus enabled to bring his book up to date. The changes in it comprise the addition of sections on the predetermination of the characteristics of dynamos, the reconstruction of the sections dealing with descriptions of dynamos, and the addition of further practical data. Descriptions of many now obsolete machines and of early experiments have been omitted. Beginning with a sketch of the capabilities of electric transmission of energy in utilising water-power, the first chapter opens with a few general principles, and in the course of this chapter a very clear explanation is given of the fundamental facts concerning an ideal simple system of electric motor and dynamo. Chapter II. deals with armature winding and calculations of the electromotive force determined by given dimensions and arrangements. Chapter III. brings us to discussions of the reversibility of dynamos, internal and external losses in conversion of energy, and efficiency of motors. Chapter IV. is largely occupied with a lucid description of the author's method of calculation for the predetermination of the characteristics of dynamos. Considering the method as a practical one, that is one fitted for the workshop or drawing office, it is undoubtedly a valuable method; but it is confessedly empirical, in the sense that arbitrary assumptions have to be made as to the nature of the magnetic leakage and the relation of magnetic resistance to density of induction for the magnetic circuit of the dynamo. Despite all that has been done to elucidate magnetic phenomena, the magnetic circuit still awaits its Ohm to do for it a service similar to that which this savant did for the electric one. But in the interval between complete ignorance and entire knowledge there is a region in which empirical methods of working have a useful field.

The structural development of dynamos and motors is an excellent instance of the fact that practice precedes theory in many, if not all, cases of practical invention; and that just sufficient grasp of the phenomena to present its fundamental facts to the mind, often affords the necessary foundation for invention. For this reason we do not want to be captious and split straws on the question whether the manner of presenting the facts, and of theorising on the basis of a magnetic analogue of Ohm's law, is really the best mode of treating the subject. Magnetic phenomena are more allied to electrostatic than to electro-kinetic facts in many ways; but it seems hardly advisable to raise a standard of revolt against a method which has become a very generally accepted one, unless something better can be put into its place. Chapter V. opens with an account of Prof. S. P. Thompson's useful methods of presenting graphically the laws of maximum activity and maximum efficiency of motors, and passes on to consider self-government of motors, and the employment of the compound dynamo as a motor. Chapter VI. deals with classification of systems of motors, self-regulation, distribution of power at constant pressure and at constant current, and contains an academical discussion of the effects of a leaky line and theoretical calculations of the efficiency of various arrangements. The next two chapters deal with the conducting circuit, and introduce Prof. Forbes' calculations for most economical sizes of conductors. The ninth chapter contains some very interesting comparisons of the relative cost of transmission of power by wire rope, electricity, water and air. The tenth and eleventh chapters are occupied with descriptions of dynamos and short histories of some early electric railways. The recent development of electric traction in America is treated very briefly. There are, perhaps, two reasons for this. In the early days of such work as this there is much that is of transient interest, but not so permanently settled in character as to make it desirable to place it on record in a text book, or it may be that the author considers that the methods of overhead supply there chiefly in vogue will not find any very extensive use in other countries. It is probable that in England at least electric traction is awaiting the perfection of an entirely efficient and satisfactory conduit system to make it more forward; or a combination of conduit and battery system which will enable cars to carry a reserve of energy for shunting purposes. The overhead wire systems are hardly more than pioneer methods which will in time give way to more solid constructions. But it can hardly be doubted by anyone who reviews the facts that electric traction is destined to become an enterprise of vast magnitude. When Mr. Kapp's excellent book has run into a third or fourth edition he may have to record some advances which will bring us within sensible distance of electric traction on railroads at speeds equal to or greater than those now usual. At present we are at the beginning of the work; but at all stages it will be of assistance to have the subject fully treated in a text-book; and this book of Mr. Kapp's places an excellent *résumé* of existing knowledge before the reader.

ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 381.)

§ 10. **Transformers at Milan.**—Although the central station at Milan was designed originally on the lines of an Edison direct-current low-pressure station, it has been found essential to supplement the direct-current plant by an alternating transformer system to reach the outlying districts of the City. There are at the present time (1890) two combined engines and alternators by Ganz in the Milan central station, which machines are generally similar in arrangement, although slightly different in details to the steam dynamos at Leghorn. These alternators are of the 80 kilowatt size, driven direct by high-pressure engines at a speed of 250 revolutions, and generating a 40-ampere primary current at 2,000 volt pressure. There are no separate excitors, but the alternators take exciting current to the amount of 28 amperes or so at 110 volts from the Edison low-pressure mains. These machines, of which one is a reserve on the other, feed, with the usual Ganz regulating arrangements, into one single underground conductor of the Siemens concentric pattern, which runs from the station in the Via St. Radegonda to the Dalverme and Fossati Theatres, about 1¼ miles, or 1,800 metres from the station. In the Dalverme Theatre there is a bank of eleven transformers of the 7·5 kilowatt size, and in the Fossati Theatre two such transformers; these transformers feed between them about 1,300 incandescent lamps of 16 candle-power, 8 candle-power, and 10 candle-power. The cable carrying the primary current has a cross sectional area of 28 square millimetres in each member. The insulation after three years of working is very high, and is between 3,000 and 5,000 megohms per kilometre.

The transformers are of the latest pattern, as described in foregoing sections, and the arrangement for maintaining a constant potential at the supply end of the main is similar to that employed at Rome. The plant has been in perfectly satisfactory operation for three years, and will, no doubt, in time be greatly extended.

§ 11. **Other Transformer Stations by Ganz.**—The distribution of electrical energy by alternating-current transformers is making very considerable progress in Italy, under the system of Zipernowsky, Déri, and Bláthy. The list on next page gives the locality and approximate output (in 1890) of these stations in Italy. From this table it will be seen that at the date of writing (1890) the output of all the stations taken together, which work an alternating system, is about 4,000 horse-power, or some 3,220 kilowatts, and will in the immediate present be very greatly extended in consequence of the advantages offered by this system in utilising water power. Already, as is well-known, a very large alternating plant is being arranged at Tivoli, near Rome, which is to be operated by water power, and to furnish current for lighting purposes in the City of Rome.

At Marienbad there is a transformer station also operated by similar plant, which was inaugurated in May, 1889. Street

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lighting is done by 36 alternate-current arc lamps, and by incandescence lamps, and about 1,800 slow lamps of 16 candle-power employed at private houses worked off a transformer system. The station is situated about a mile and a quarter from the centre of the town, and is a brick building, having an area of 600 square yards and divided into a boiler-house and engine-room. The dynamos are Ganz alternators of 50,000 watts output each. Four such dynamos are driven direct by Westinghouse engines made by Alley and Maclellan, in Glasgow. The excitors are driven by belts off the alternators. The alternators generate current at a pressure of 2,000 volts. The primary and secondary conductors are carried overhead on posts separated by about 35 yards, and the transformers are contained in weathertight receptacles on posts also. Three alternators are usually coupled together in parallel during the heavy time of load, and one machine held as a reserve. The dynamos work perfectly well in parallel, and are put on or off the circuits by the same arrangements as those described for the Leghorn central station.

There is a small water-power transformer station at Valreas and Dieulefit, which is interesting as an example of transmission of power. Valreas (Vaucluse) and Dieulefit (Drôme) are electrically lit by means of power taken from a fall of water at Béconne, three miles from Dieulefit and nine miles from Valreas. At Béconne there are a couple of horizontal turbines, which yield each about 50 horse-power at 180 turns per minute. Each turbine drives a Ganz alternator of 24 kilowatts output and an excitor of three kilowatts output. The regulation of the turbines is effected by an hydraulic regulator by Bouvier, and the regulation of the primary electro-motive force at the consumption end of the line is effected by the use of a mercury cup rheostat as before described.

The primary current is conveyed by a bare overhead silicon-bronze wire, of 3·2 millimetres diameter (No. 10, B.W.G.), and a resistance of 11·8 ohms to Dieulefit, and to Valreas by a similar wire of 6·6 millimetres in diameter (No. 3 B.W.G.) and 16·1 ohms resistance. The wires are carried on double-shed porcelain insulators. The transformers are held in iron cases carried on posts, and from them are distributed insulated secondary wires to the houses. The station, although very small, offers an interesting example of the conveyance and utilisation of water power by transformer plant.

In Paris, the Continental Edison Company carry out the lighting of the Palais de l'Élysée from their station situated about one mile and a quarter away, by means of Ganz alternators and transformers. Two alternators of 90 kilowatts and two of 24 kilowatts furnish current for 1,800 glow lamps in the Palace. The primary current is conveyed at a pressure of 2,000 volts by an underground concentric cable. The pressure is kept constant at the far end by the usual regulation of the exciting current, which is taken off from the direct-current machines in the same station. The four machines can be worked in parallel on to the single main, and the switchboard is arranged to permit this to be done.

Locality and Approximate Output of Central Stations in Italy.

Station.	Motive power.	Full capacity in kilowatts.
Alanzo	Water	100
Bagni	,,	15
Bassano	,,	50
Cuneo	,,	150
Palermo	,,	40
Perdehohe	,,	30
Terni	,,	240
Trevisa	,,	60
Taglicozzo	,,	15
Leghorn	Steam	240
Milan	,,	150
Rome	,,	1,440
Syracuse	,,	150
Turin	,,	300
Venice	,,	160

(To be continued.)

THE EDINBURGH EXHIBITION.

The exhibit of the Electrical Engineering Corporation includes Statter and Brunton constant-current dynamo (Fig. 1) as supplied for driving tramways in the Via Flaminia at Rome. This machine is fitted with Statter and Brunton's patent automatic regulator, and maintains a constant current of 60 amperes with a maximum pressure of 750 volts at 750 revolutions. It will be seen from Fig. 1 that the machine has double circuit field-magnets, these are of forged "magnet" iron, and are machined all over; the pole-pieces are of cast iron, of ample section, and the joint between the wrought and cast iron is very carefully fitted, and being made on the end as well as the side of the slab, the area at joint is twice the sectional area of the slab.

The insulation resistance of these machines is very high, usually about ten megohms for the whole machine, and is obtained by the employment of mica. It is, therefore, a permanently high resistance, and does not depend upon paper soaked with shellac, which, though giving a very high insulation when dry, readily absorbs moisture, and so loses its insulating properties.

The armature is built of Swedish charcoal sheet, and is well ventilated; the winding is driven directly from the spindle, and

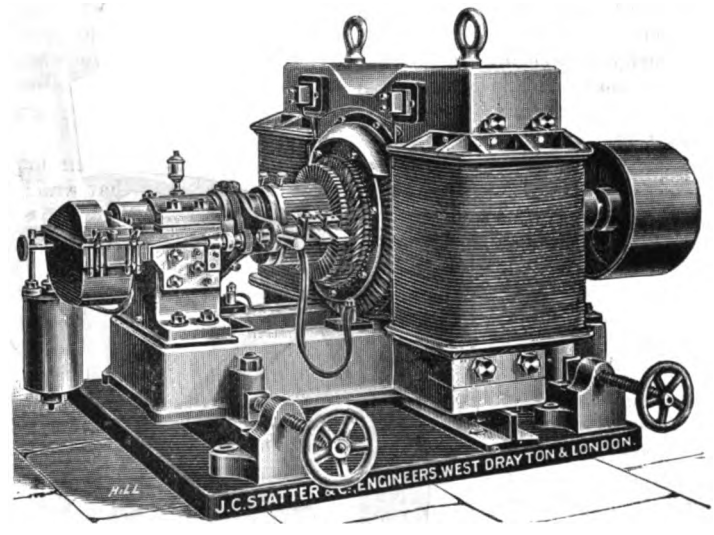

Fig. 1.

very firmly held in order to withstand the sudden alterations of load which take place in this machine when used for traction purposes.

In working, these machines run without heating, and the current is maintained at constant value with great accuracy. Sir Frederic Bramwell, in his report on the Northfleet tramways, states of this constant current generator:—"The dynamo is self-adjusting in its maintenance of a constant current. It is extremely interesting to watch the sensitiveness of this apparatus, and the manner in which it even forestalls the action of the engine-governor" (a sensitive high-speed governor). There are also two self-regulating series motors; these are of the same type as the generator shown in Fig. 1, and are provided with patent regulators, whereby the movement of the brushes is controlled by the action of a sensitive centrifugal governor. In all generators and motors made on this system the mechanism for regulating the current is enclosed in a small cast-iron oil-bath attached to the commutator end bearing, and neither the solenoid in the case of the generator, nor the centrifugal governor in the case of the motor, are required to exert any sensible amount of force, they merely determine the engagement of one or other of the driving pawls. It is in this manner that great sensitiveness is obtained.

The Statter-Brunton self-regulating gear has been described before in our columns, but it has been perfected in constructional details and made more compact. It can now be adjusted in a few moments, for a machine running in either direction all

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working parts have been made amply strong, and as they work in oil there is practically no wear and tear.

The Corporation make these generators in nine standard sizes ranging from 3 kilowatts up to 80 kilowatts, and a corresponding series of constant-current motors ranging from 4½ horse-power up to 110 horse-power.

The constant-current generator is also employed for driving arc lights in series, and for this purpose standard sizes are made capable of maintaining from 6 arc lamps in the smallest size up to 120 in the largest, each of 2,000 candle-power.

This Corporation show their constant current motors applied to a hoist. The adaptability of their constant system is well illustrated by this application; the hoist shown is capable of lifting one ton at a speed of 100ft. per minute. The regulation patent; the governor is keyed directly on to the crank shaft, and is shown in Fig. 2. It acts directly on the cut-off of the valve, and while completely controlling the speed of the engine gives excellent results in point of economy in steam consumption. The engine is simple, since the available boiler pressure at the Exhibition is low. The Corporation make tandem compound engines of similar design with an improved piston valve, and would have preferred to exhibit one of these engines had the steam pressure supplied by the executive of the Exhibition been higher. Both simple and compound engines are made in eight standard sizes. A two horse-power nominal Atkinson gas engine combined with a 40-light compound-wound dynamo is also shown and used to drive some Statter arc lamps in parallel; the set forms a very compact

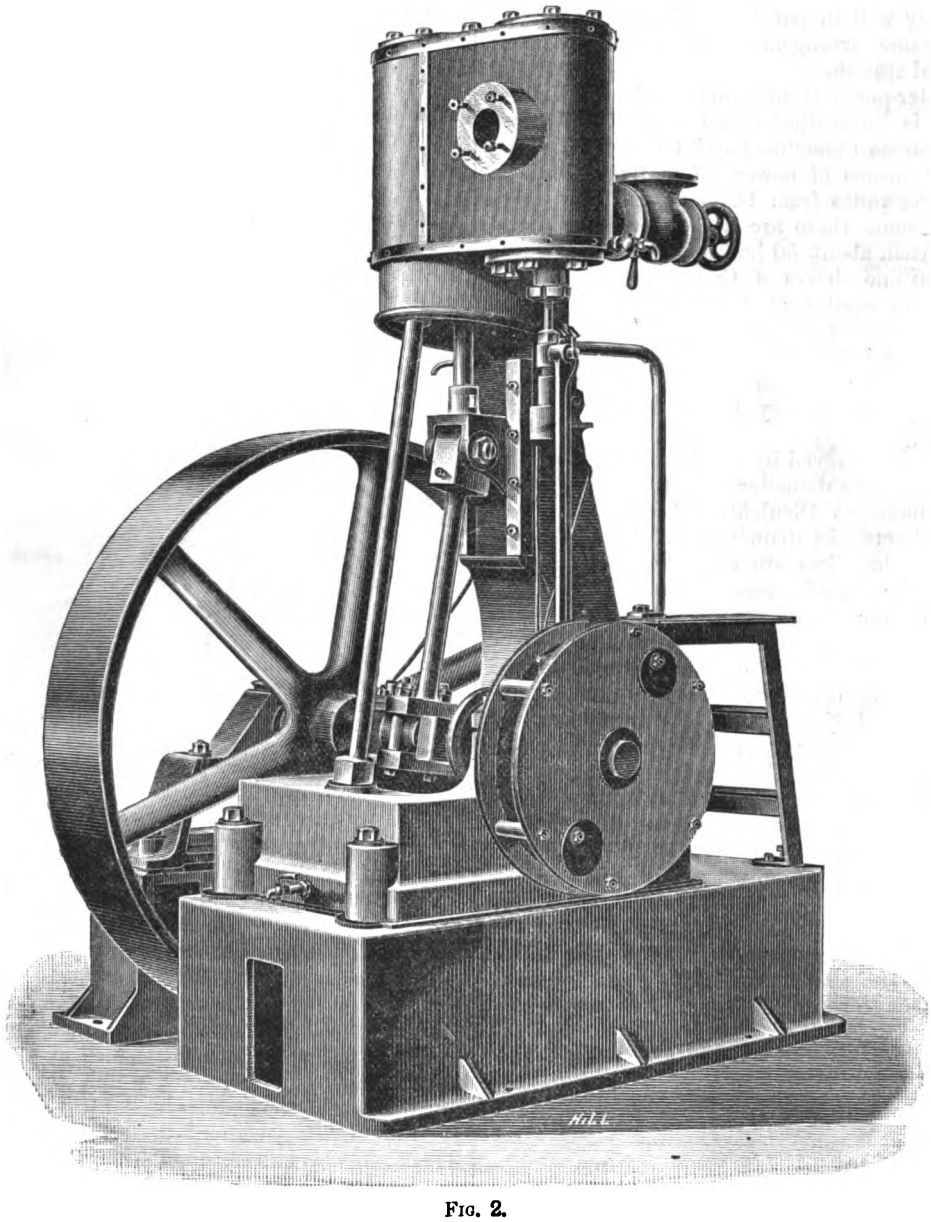

Fig. 2.

of the motor is by hand, and the motion of starting, stopping, and reversing is performed by the movement of a single lever, and is effected with great ease; the current is never switched off the machine during working, but after the hoist is done with the brushes are placed at right angles to the neutral point. The motor then comes to rest, and absorbs only the volts due to its resistance; it is then switched out of the circuit. Heavy sparking at the switches—inherent to all parallel systems of power distribution—is entirely avoided, and is one of the many advantages of the system. The hoist is wound for a constant current of 60 amperes, and absorbs 200 volts when fully loaded. The exhibit also includes a high-speed engine with automatic expansion governor (Turner-Hartnell's) plant for lighting private houses, and will be specially useful where space is limited.

This exhibit also includes a 20in. projector, made in accordance with the Admiralty specification. It is well finished in every detail, and furnished with signalling gear and with Statter and Brunton's patent diverging gear.

From their offices at the Exhibition the Corporation have carried out the lighting of the yacht "Katoomba," belonging to Kenneth M. Clark, Esq. Fig. 3 shows the set supplied for generating the current. The dynamo is compound wound, and gives 60 volts and 18 amperes at 1,400 revolutions; the engine is the smallest of the standard sizes made by the Corporation; the cylinder diameter is 3in. and the stroke 4in.,

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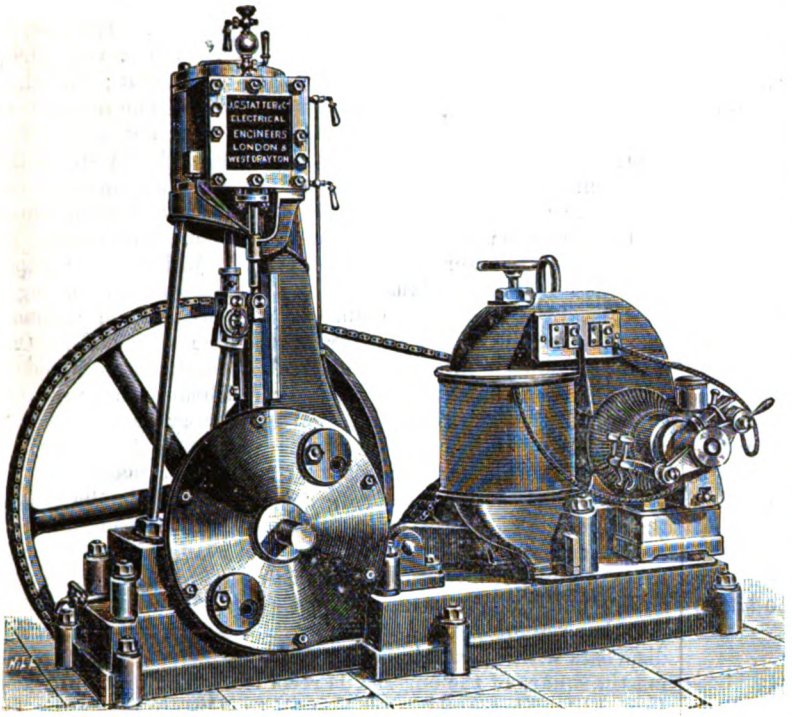

FIG. 3.

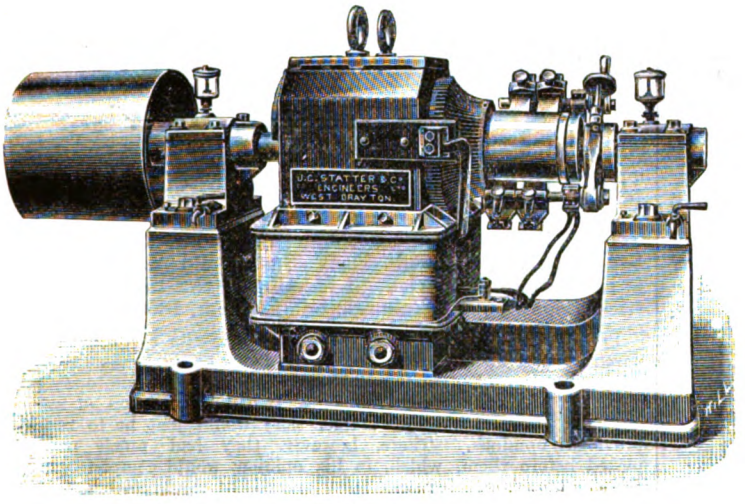

FIG. 4

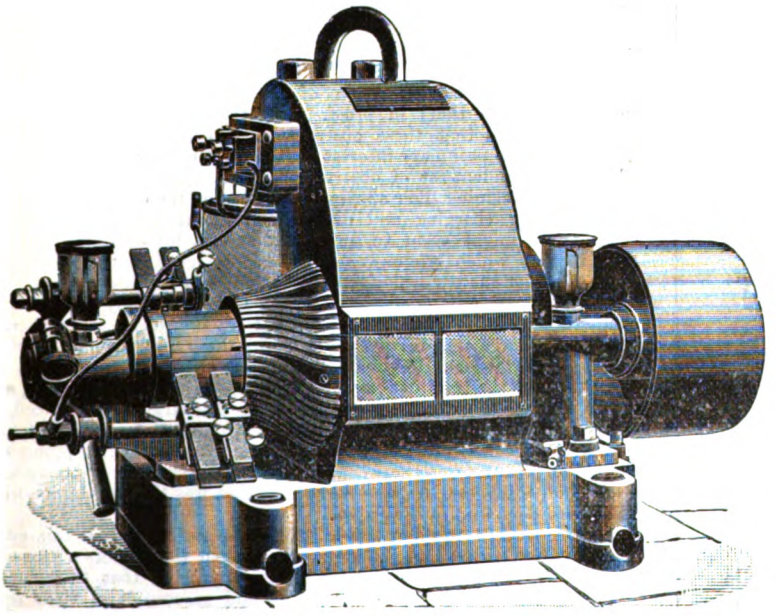

FIG. 5.

the whole set goes in a space of 2ft. by 3ft. 6in. by 3ft. high. Fig. 4 shows the standard type of dynamo manufactured by the Corporation for all sizes beyond 4 kilowatts, and Fig. 5 shows the type for all sizes up to 4 kilowatts. The dynamo of the larger type exhibited at the Corporation's stand has an output of 240 amperes at 120 volts, the field-magnets are made entirely of soft wrought-iron well annealed, and the armature of the softest Swedish charcoal iron. The Corporation make these machines for voltages up to 250 in eight standard sizes, ranging from six kilowatts up to 77 kilowatts, and they are described in their catalogue as type "B" dynamos. The smaller machines made to the design shown in Fig. 5 are in three standard sizes, and are described as type "A" dynamos. The armature of the "B" machines are of the drum type, and of the "A" machines cylinder type. Fig. 6 shows a geared motor supplied by the Corporation; it has a self-contained counter-shaft, and the power may be taken off it by means of belt, ropes, or pitch chains at a low speed.

The electric launches of the General Electric Power and Traction Company are running from 10:30 a.m. till 10:30 p.m.; each boat making journeys of an average of 35 miles a day. The accumulators are charged at night, the duration of the charging being from 6 to 7 hours. A charging current of from 25 to 30 amperes is used, at 100 to 125 volts. It is found that the four boats can be charged six times with a consumption of 4 tons of coal, which is supplied at 13s. per ton; £2s. 10s. per week is paid for the use of the engine. An average of 6,000 passengers is carried per week.

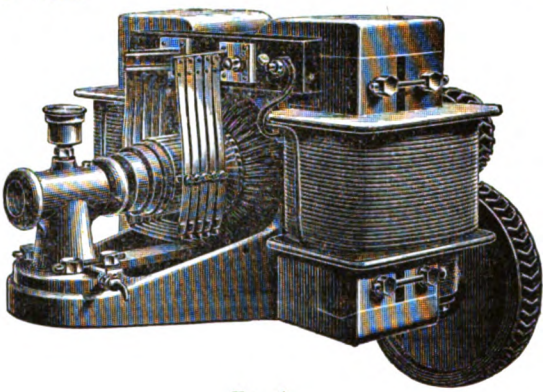

FIG. 6.

The General Electric Power and Traction Company also exhibit a good assortment of Immisch motors and dynamos, resistances, fittings for colliery work, lightning arresters, B type E.P.S. secondary batteries and propellers for their electric launches, as well as some of their motors coupled to mining machinery, which are shown in operation. This company's standard pattern of Immisch motors and dynamos is well known in mining, launch, and traction work. Different sizes are shown suitable for belt or chain driving, and in addition is exhibited a 25 horse-power Immisch motor, mining type, mounted on a suitable cast-iron trolley coupled to an Ingersoll rock drill, with a link chain for boring in any position in mines and quarries, &c. The motor is supplied with carbon contacts at right angles to the commutator, so that the motor will run in either direction without having to alter the brushes. At a speed of 1,200 per minute, with 150 volts and 16 amperes, the motor will give out 2·5 B horse-power; and when coupled to the above-mentioned drill is said to bore through rock at the rate of 5 inches per minute. The motor trolley has a pair of slide or belt tightening rails, with a worm

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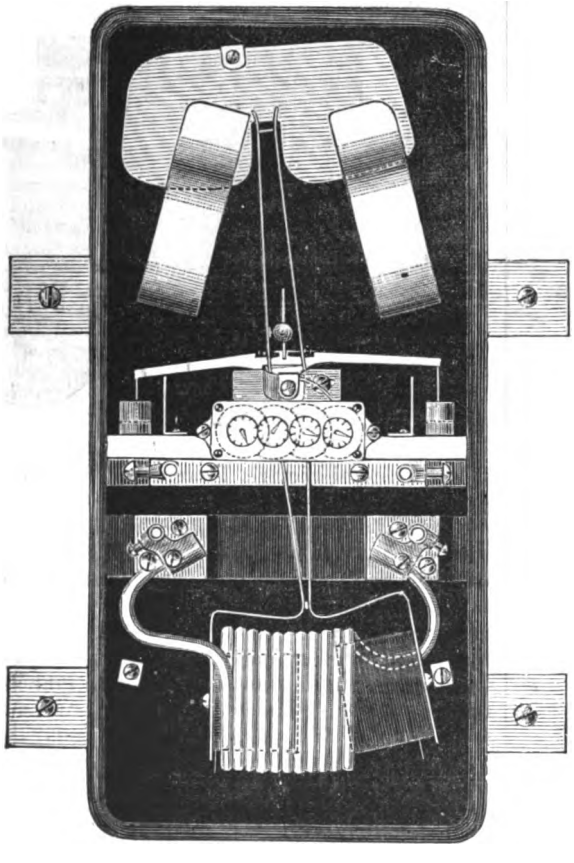
screw fitted to same and motor; hence the motor can be moved in a backward or forward motion as it is desired by actuating the worm handle. This firm have also a ½ horse-power motor driving a 36in. Blackman air propeller, as well as another 2·5 B horse-power motor, also mining type, driving a high-speed mine pump, with three rams, 4in. by 9in., throwing 3,280 gallons of water per minute through a head of 600ft. at the rate of 45 strokes per minute. They show a 4 horse-power motor of the horizontal pattern, similar to those used to propel the electric launches on the canal. There is also a 10 horse-power motor for a tram car, to carry 52 passengers, also of the horizontal type. It may be worth while to remark that all these motors are wound in series, the torque at the moment of starting being the maximum. For constant-current transmission the firm exhibit a series motor with an automatic arrangement for cutting out a certain number of layers of the field-magnet coils, thereby reducing the field magnetism. Amongst the electrical accessories are to be seen polished slate distributing switches, with double pole cut-outs, or fuses, for mine work; also colliery resistances with a very ingenious spark arrester for altering resistance in circuit. For the lighting of mines the company exhibit some fittings which are of a very strong and durable nature, the chief point being to externally protect the lamps from falling debris, &c.

PROF. ELIHU THOMSON'S ELECTRIC METER.

Prof. Thomson has invented an oscillating meter, the action of which depends upon the principle suggested by Ayrton and Perry, and put into a practical form by Siemens and by Hookham.



Prof. Elihu Thomson's Oscillating Meter.

It presents an advantage over these on account of the greater mechanical facilities which a pendulum offers for a slow movement, as compared with any arrangement for continuous rotatory movement. The Hookham meter, for example, while an excellent device for measuring a few amperes, requires great nicety of construction, and delicacy of pivoting to enable it to register one lamp. The motive force is then comparable to the friction, which is practically a constant quantity. The disc, or armature, then moves at its lowest speed, and a very slight increase of friction or other retardation will stop it; though it goes merrily enough with a fair current. The account of the new meter in the *Electrical World* does not give a full description of its action, but the illustration clearly shows the arrangement. A main coil carries the working current, and within it swing two shunt-coils, forming the bob of a pendulum. This is hung on knife edges, and works a counter-train, on whose dials the number of swings are recorded. The amplitude of the vibrations is limited by elastic stops. The swing is kept up by the alternate making and breaking of a shunt-current through one or other of the fine wire coils. One naturally objects to make and break of contacts in a meter, especially in shunt circuits; but Prof. Thomson has probably controlled the sparking by some satisfactory method. The upper part of the pendulum carries a sheet of copper, which passes between the poles of two permanent magnets. We presume that the weight of this nearly counterbalances that of the shunt coils, thus giving a slow period of vibration, and this is further controlled by dash-pots. The whole arrangement is, therefore, rather a reciprocating electric motor than an electric clock; and though it at first appears to be of the Aron class, it rather resembles the balance wheel meter of Prof. Boys, but dispenses with his admirable device by which the current, and not the square of the current, is recorded. The problem which Prof. Elihu Thomson has set himself to solve, in attempting to balance the various forces of electro-dynamic action, air friction, Foucault current retardation, elastic recoil, mechanical friction, and the considerable momentum of the moving parts, is no easy one, and we wish we had further details of the means he has adopted to place before our readers.

THE WORKING EFFICIENCY OF SECONDARY CELLS.

The following is the discussion on the Paper by Prof. Ayrton and Messrs. C. G. Lamb, E. W. Smith, and M. W. Woods, read at the Extraordinary General Meeting of the Institution of Electrical Engineers at Edinburgh, on July 16th, 1890:—

Prof. PERRY said he saw that nobody in the room was really prepared to enter upon a discussion of the Paper at the present moment. It was one of those Papers it was utterly impossible for one to say anything about on the spur of the moment. It had taken years of work; and anything they might say at that time would just be to repeat one's previous opinions. There, however, they had much new matter placed before them, which, in his opinion, would completely transform their old notions. He was sure everybody would feel astonished at the large working efficiency that had been obtained in cells when in working condition. They had learned from that Paper one very important lesson—that they must not take the cells blindly, as he himself had done some five or six years ago—and merely charge them up and discharge them without inquiring closely into their working effects. It was a most important thing to learn, that even in seven days for charging and discharging, the cells had not yet reached a state that they could tell what their efficiency was. He had a notion of that before, but there they had actual figures given them in proof. One thing of enormous importance was the fact that these observations had been made by people having actually no pecuniary interest in them; but they liked to have an absolutely independent set of observations. The ingenuity that had been shown in thus designing their apparatus for keeping the current absolutely constant during charging and discharging, might appear as a waste of energy. It might seem to some that such a lot of time should be devoted to work which is simply for the general good of the profession, and not at all for the particular good of the authors of these Papers. He was sure that Prof. Ayrton and his students had exceedingly little to gain in comparison with the enormous amount of work they had accomplished in their Paper. There was hardly anything in the Paper that was not of enormous importance. He should like to see somebody who could do what he thought the Institute ought to take steps to have accomplished, and that was, during the continuous charging or discharging of any cell, to distinguish between resistance and back-electromotive force. He found they even had been forced to go back on their own plan of stopping the current; but to distinguish between back-electromotive force and resistance was the chief thing, and he was sorry that that was the one thing which had not been gone into in the Paper.

Mr. KAPP said it was impossible to discuss a Paper like this on a moment's notice, seeing that the inquiry had taken the authors a year and a-half to work out their investigations. He suggested that they should not close the discussion that day, but should resume it at their next ordinary meeting, when everybody would have an opportunity of studying the Paper, and it would then receive the amount of attention which it deserved.

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Lord BURY said his connection with secondary batteries was a practical one. He found that there was a great prejudice existing against secondary batteries, and a great belief that their efficiency was much less than it appeared to be. He was one of a few gentlemen who applied secondary batteries to electric traction. Whenever they got what they thought an improvement they were not content with trying that improvement, without trying it to the breaking strain. If in many instances cells delivered over to them really resisted their intense breaking power, then they found in the course of time—in the course of four or five years' experience—that they really could rely upon the cells to a much greater extent than was supposed by those outside. In the practical development of these cells there has been great improvement. Mr. Barbour Starkey had lately initiated an improvement in secondary cells, by which the rough usage to which they are subjected in the course of tramway traction might be much improved. As far as they had been able to test it, and they had done so very severely, they thought it would be a great and material improvement. They, as practical users of cells, had come to very much the same conclusion that, as he gathered from Prof. Perry and the reader of the Paper (Mr. Lamb), the gentlemen who had been making these investigations had arrived at—viz., that the efficiency of the cells themselves is much more reliable and higher than was at first supposed. He had no doubt that the test and investigations to which the secondary battery would now be subjected would still further prove that truth.

The CHAIRMAN said he quite agreed that they should have a full discussion on that important matter at a subsequent meeting; but they wished to take advantage of the present gathering to extract as much as they could from those present as to the discovery from the practical side of these cells.

Mr. BARBOUR STARKEY said he had only tried to overcome difficulties as he saw them arise and become almost intolerable. He had tried various experiments, but, generally speaking, it had not been work of a very severe character. The use of carbonate of soda in accumulators he had found of great value. When they had to stand for a long time, he was struck by the way that scaling of the heavy discharges took place. He had tried various experiments, one of which might seem very crude to electrical engineers. It was to put in a substance of great resistance—plaster of Paris—between the plates; and, to make it more porous, he tried various materials to mix with it. The first time he tried it was last year in Scotland, when he put into the cells a mixture of 2½ parts of fine sawdust to one part of plaster of Paris. That mixture he placed in the cells in a dry state, and added a little nitric acid and carbonate of soda. He was rather surprised, when he returned at the end of June, to find when he put on the switch that the lights went up as brightly as when he left in the autumn. He had at first thought that plaster of Paris would not be a good insulating material, but he now found that he had been mistaken.

Mr. FRASER, engineer to the Electric Traction Company, London, said that three years ago he had experimented in the variation of resistance in reference to current. They all knew the formula for obtaining the maximum work with the discharge of an accumulator, supposing that the resistance is of a given value. Taking the cell fully charged, its E.M.F. would be something between 2·1 and 2·2 volts. Take it at 2·15. If they differentiated the formula for the maximum work, that gave the current to be equal to E by 2 R. If it were the case, an accumulator whose electromotive force would be 2·15, its resistance ·C05, that was $\frac{5}{1000}$ of an ohm, should give out maximum work with 215 amperes, and potential difference =1,075; maximum work, however, corresponded to 300 amperes, and short-circuited, should give them a maximum current of discharge of 430 amperes, which it would be possible to obtain from such an accumulator. He had short-circuited the cell, and instead of getting 430 amperes as the maximum current, he got between 500 and 600, showing absolutely that the internal resistance of that accumulator, which with the ordinary working current to which they put it was ·005 ohm, or $\frac{5}{1000}$ ohm, must have fallen in an increase of current to half of the value; otherwise it would have been impossible for it to give out that current of between 500 and 600 amperes. Further, at that time he had tried in a practical way to discover how that resistance varied, and a very convenient form presented itself. The resistance of an accumulator varied in inverse proportion to the current which it gave out. Allusion had been made in the Paper to the difficulty of reading the potential difference of one element. That, of course, was exceedingly difficult; but he would suggest that instead of making the experiments with one or two cells, it should be made with 100 or 200. That would obviate that difficulty completely, and it would further give them the advantage of testing and comparing those cells between themselves; for if they had a large number of cells they would, he was afraid, very soon discover a want of uniformity in the construction of them; so great, indeed, that the one standard cell they might select would stand as no criterion of the other 99 cells that went to make up the 100. The rough treatment which accumulators had in heavy traction work, and the variation of current they had to give out, unless the cells were exceedingly well made indeed, and unless there was great uniformity when the cells were delivered, he was sorry to say that the plates did begin to scale sooner than they would like to see them; and they also began to buckle sooner, and they had to take out the plates. Mr. Barbour Starkey proposed that they should fill up the whole of the space between the plates inside the receptacle with a mixture of plaster of Paris and sawdust. Knowing the great trouble which was caused by the buckling of the plates—he was speaking now of having used 2,400 cells in the last year, and many thousands of cells on the Continent and in the United States and of having manufactured them also—he had been happy to give that arrangement a good trial. So he prepared four accumulators filled with a composition of two parts of plaster of Paris and one of fine sawdust. He was particularly careful to let it drop in gently, so as to have an even distribution of the mixture, and he was specially careful in filling it in that the receptacle should not be shaken to make it heavy at the bottom. He filled it all full, leaving forks in the cell until it was filled with the composition, and then he took out the forks one by one and filled the cavity left. He was at first anxious to know what effect the mixture would have upon the internal resistance and the weight of the cell. He was pleased to find that its effect upon the internal resistance was small. It did increase the resistance, but only to 5 or 6 per cent. The weight had also increased in a still smaller degree, somewhat; for one double cell with its liquid weighed 104lbs. made up in the ordinary way, and the same cell filled with plaster of Paris and sawdust, and absorbing very nearly the same amount of liquid, weighed 108lbs. He was so satisfied with the four cells that he had prepared a complete battery of 96 cells. That battery had been in use about three months, and the fault that he had to find with it was that its extra resistance for high currents—30, 35, 38, or 40 amperes—became serious. It also became a source of inconvenience with the other batteries. One battery out of 12 to have a little more resistance than the others. What, however, he hoped to see was this, and if it came out as he expected he would be well repaid for the trouble—he hoped to see that battery at the end of a year, after he had given it 360 or 365 charges. If it still did its work at the end of that period he would be very pleased to compliment Mr. Barbour Starkey.

After a few words from M. HOSPITALIER, Paris, and Mr. MASSEY,

Mr. FRASER asked Mr. Lambe if he had made any experiments to determine the curve of degrees of potential of an accumulator immediately after it had been disconnected from its charging dynamo? That he (Mr. Fraser) had done some years ago, and he found that it varied in the same way that gravity itself varied—that was, it fell rapidly, then less rapidly, still less rapidly, and gradually died away. In fact, the common gravitation formula, $V t - \frac{a t^2}{2}$, represented that curve. If they observed the fall during one period, it was sufficient to give them the value of the acceleration, and also the value of the initial velocity.

Mr. SWAN said that, seeing accumulators or secondary cells were at present attracting more attention for traction and lighting purposes, it would be interesting to have some careful scientific tests made in the laboratory, in which the conditions under which the cells themselves were used would be reproduced—he meant with respect to the shaking. The question of the working efficiency of the accumulators was not one that could be found out by a single cell. He was shown the other day the effect of a slight blow on two different kinds of plates. One of the old used cells was taken and knocked up against the wall, and he thought 25 or 30 per cent. of the plugs came out. Whatever the efficiency of an ordinary cell might be under ordinary circumstances, the efficiency after a shock of that kind must be 25 or 30 per cent. less. He had been told by one who had to do with traction that one of the greatest difficulties in actual traction was the danger of one car making a slight tilt or two cars accidentally knocking together.

The CHAIRMAN said he was bound to confess that at the present day there was no subject of greater importance to the electrical engineer than that of the proper performance of secondary batteries. They were coming into use more and more every day, not only for the comfort of those who had their houses lighted by electricity, but for those who travelled by railway trains and electric tramway cars. In every branch of electrical engineering the secondary cells were being used more and more every day. The great prejudice, and there was great prejudice, against the use of these secondary cells was due to the inherent opinion that a secondary battery was a very inefficient instrument; and although the few had long felt that a secondary battery was not quite so efficient, the majority would feel that the authors of the Paper had done a very great work indeed, and that they had established by unmistakable figures the truth that as a machine the secondary battery was not a very inefficient one. Again, it had an important bearing on the question of the distribution of electricity over large areas for lighting towns. The favourite system at present was to distribute currents over wide areas by alternating currents; but there were those who believed in the secondary cells, and who believed that in the future the secondary battery would knock out of the field the secondary generator. He was bound to say that there were certain districts and areas which could be as efficiently, if not more efficiently, lighted by batteries than by any other process. The great defect that had been developed in those systems of distribution by secondary batteries had been their very low efficiency, and that had been attributed to the inefficiency of the battery. But he had very great reason to think that the very low efficiency of these systems of distribution by secondary batteries was due, not to the system itself, but to the means adopted for charging and discharging the cells. There was one curious fallacy that was very widespread indeed, and that was this, that because in charging a secondary battery they worked up to 2·4 or 2·5 volts, and in discharging that battery they got down to about 2·2 or 2·1 volts, therefore they had at once a loss of efficiency of 25 per cent. in that battery. It was one of the most absurd fallacies ever indulged in, and it was shown by the tables in the Paper that it was theoretically impossible to get as much out of their battery as they put into it. Practical men had arrived at very much the same conclusions as the authors of the Paper, and it had always been a great satisfaction to him to find that practical and scientific men were agreed. His cells had been in his house now for six years, and he had never had a flickering of the light. That was entirely owing to the fact that they had been treated, as secondary cells should always be treated, with great care and discretion. Practice had introduced another test, which was of very great value, and one to which he would urge the greatest attention, and that was always to watch the performance of the electric current. Above all, they should never omit to measure the density of their liquid by means of a hydrometer. Mr. Barbour Starkey had referred to the fact that he had introduced soda into his cells. He was very much struck, on spending a few days with Mr. Barbour

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Starkey at Bridgenorth, to see the beautiful condition his plates were brought to. He had assured him that it was entirely due to the application of soda. He (the Chairman) was so satisfied that there was something in this, that he organised a long series of experiments, extending over two years, to determine the proper proportions between soda and sulphuric acid; and the conclusion he came to was that, in all secondary cells, it took 45 pints of electrolyte, which was made up of 39 pints of water, 5 pints of sulphuric acid, and 1 pint of saturated solution of sulphate of soda. As to Mr. Fraser's remarks, he wished he had remembered that, in 1884, there was a Paper read before the Royal Society by himself, where he showed that the internal resistance of a secondary cell varied inversely with the current; and in a Paper read last year at the Society of Arts he gave that formula, and showed that as they increased the current so the resistance diminished. He would point out that this automatic apparatus should be of great practical utility. It reminded him of an invention brought before them some years ago by Mr. Edmunds. There they had the future success of secondary batteries for the distribution of currents for electric lighting. If they could by such an automatic apparatus as that, or by that of Mr. Edmunds, bring in a cell when it wanted a charge, and let it work its way out when it had got its charge, they would get rid of that waste of energy that was now so prominent and so marked, not a waste of energy in the battery itself, but a waste of energy in charging the cells.

Mr. E. W. SMITH having briefly replied on the discussion,

Mr. MURRAY MILLMAIN, Melbourne, requested the authors of the Papers to be prepared at the next meeting of the Institution to tell them the instruments they had used, and give a history of the cells upon which they had experimented, as he had before now been led astray by the results of investigations in consequence of the instruments used not being thoroughly explained.

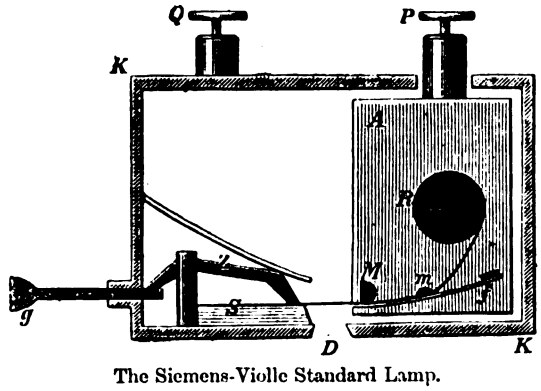
The Conference then adjourned for the day, it being understood that the Paper will be again discussed at the next ordinary meeting of the Institution in London, after members have had an opportunity of studying and mastering its contents.

ERRATA.—The authors have pointed out that a few errors appeared in their Paper as originally issued. In our last issue, in page 384, column 1 and last line but one, for "0·045 ohm" read "0·0045 ohm;" in the second column, line 5, for "0·11 ohm" read "0·011 ohm;" on page 385, column 1, for "0·038 ohm" read "0·0038 ohm;" and on line 5 for "0·09 ohm" read "0·009 ohm."

THE SIEMENS-VIOLLE STANDARD LAMP.*

BY DR. E. LIEBENTHAL.

The forms up to the present suggested for obtaining the unit of light passed by the Paris Congress have all of them many inconveniences, being both difficult to manage and most of them costly.



The Siemens-Violle Standard Lamp.

That illustrated in the accompanying figure has been specially designed to overcome these difficulties. A stand some 4in. high carries a box, K K, shown full size in the figure. On the bottom of the box is an insulated metal plate, A, on which is a small drum of platinum strip, R, a movable half cylinder, *m*, a larger fixed one, M, and a terminal, P. The strip passes under M and *m*, against which it is pressed by the spring *f*, and thence to the plate S, where it is clamped by the claw Z. The strip is now stretched by turning *m* backwards, and on passing a current through the instrument the platinum strip is melted, the light being observed through the aperture D. The handle *g* is now pressed, pushing S and Z forward, and at the same time lifting Z. On pulling *g* back, Z falls again, clipping the end of the platinum, and drawing on a fresh piece for the next reading.

The lamp does not absolutely fulfil the requirements of the Congress, as the source of light is platinum just melted, instead of melted platinum on the point of solidification; but, if it should be found necessary, a correction factor may be ascertained once for all. The cost is infinitesimal compared to that of the original standard, one gramme of platinum, costing about 2s. 6d., being sufficient for 50 readings. The metal is also obtained pure without difficulty, as there is, of course, no fouling due to the source of heat.

Preliminary trials with the lamp showed several small defects in the means of making contact on the right-hand side; these, however, were overcome by covering M with platinum, and abolishing *m* altogether, the strip being tightened by manipulating *g*. It was found also that more or less tension had but very slight effect on the results obtained. The current used varied from nine amperes to as much as double, due to variation in the gauge of platinum supplied. The strip used was about 5·5 mm. broad and ·011 mm. (·44 mils.) thick. A very large number of comparisons were made against the amylacetate standard, the current being slowly augmented, and the grease-pot carrier slid along the photometer bar as the light increased, the point at which the carrier stood when the coil fused being taken as the reading. The results obtained do not agree perfectly among themselves, the mean error in 180 readings being 2·9 per cent., whereas the same observer made two amylacetate lamps agree within 0·95 per cent. The errors are attributed both to variation of the platinum standard itself, and also to the fact that just before melting the light is considerably whiter than the amyl standard.

As the final result Dr. Liebenthal gives the value of the amylacetate standard as ·569 Congress unit.

Herr v. Siemens originally gave the figure as 0·7 legal unit, but thought that this was probably too high, owing to impurities in the platinum.

From previous experiments the value of the English standard candle had been found to be 1·169 that of the amylacetate lamp, which makes the legal value of the candle ·665 legal units. On the other hand, Herr Violle himself has made the value ·54, a difference of over 20 per cent.

In conclusion Dr. Liebenthal says that owing to the colour the platinum lamp is best suited for arc-light determinations, and recommends that the platinum should only be about ·2 to ·3 mils. thick.

* Abstracted from the *Elektrotechnische Zeitschrift*.

INTERNATIONAL ELECTRICAL EXHIBITION AT FRANKFORT-ON-MAIN.

We are informed that boilers and engines with a capacity of about 2,200 horse-power have already been put down at this Exhibition. The dynamos are also in position. These will supply 1,000 arc lights and about 10,000 incandescents. It is expected that the lighting will far surpass anything that has hitherto been accomplished, and several novel and surprising effects will be shown. Besides showing the great advance which the electrical trades have made since the Vienna Exhibition, an endeavour will be made to arouse more public interest in this industry. We are therefore glad to learn that the Elektriziteits Maatschappij, Systeem de Khotinsky, Gelnhausen, besides accumulators and a collection of apparatus for installation work, will also during the time the Exhibition is open show the exceedingly interesting method by which incandescent lamps are manufactured. Visitors will thus be able to watch the details of the processes for making the carbon filaments and turning out the completed lamps.

With regard to the projected transmission of 175 horse-power from Lauffen-on-the-Neckar to the Exhibition, and the use of a potential of 30,000 volts for the purpose, Herr Popp writes to the *Finanz Herold* as follows:—

"I have for some time past experimented with currents at tensions up to 20,000 volts, and have arrived at the conclusion that the use of pressures of over 15,000 volts must always be attended by very heavy losses partly due to the leakage from one conductor to the other by way of the insulators, and partly by direct loss through the air. At 15,000 volts these losses in damp weather assume very important magnitudes. Leaving these, however, entirely out of the question, I find that the resistance of the conductor itself will occasion a fall of potential of over 4,000 volts, when a pressure of 15,000 volts is used, so that 15,000 volts at Lauffen will only give 11,000 volts available at Frankfort. Moreover, the difficulties of working out in an efficient manner so vast a project will certainly prove insuperable. I therefore regard it as absolutely incredible that the Berlin Allgemeine Elektricitäts Gesellschaft are seriously contemplating the undertaking. I am confirmed in this view by the demand which the Company makes for a copper conductor 350 km. long (outgoing and return) and 5 mm. diam. to be provided them. Such a conductor would, as you have remarked, cost quite 100,000 marks (£5,000), and there is also the possibility that the necessary poles could not be obtained. Even if some firm would furnish this free of cost by way of an exhibit, I am still convinced that the local authorities would refuse to allow the conductor to cross their land, either on the ground of danger or of interference with telephone and telegraph lines, and that the Allgemeine Elektricitäts Gesellschaft relied on something of this kind happening when they made their offer."

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THE RESISTANCE OFFERED BY GASES IN A MAGNETIC FIELD.*

BY A. WITZ.

The first results which I had the honour to submit to the Academy elating to the action of magnetic fields on Geissler tubes required completion; indeed, after having studied the effects produced by a variation of the strength of the field, and also by a variation of the position of the tube with respect to the lines of force in that field, the effect produced by an alteration in the pressure of gas in the ube was still undetermined.

The following experiments have been made in a glass cylinder two centimetres in diameter, provided with taps and adapted either for compression or rarefication of the gas contained in it. The discharge oscillated between two electrodes provided with cones of aluminium. Under a pressure of 0·6 centimetre of mercury a purple discharge was obtained; with 230 centimetres a brilliant and powerful spark formed a path of fire between the two points. For intermediate pressures a spark and a discharge were observed simultaneously.

Now the effect of the magnetic field displays itself under these varying conditions in different ways. The discharge is diverted in accordance with the laws of electro-dynamics, the spark, however, is not; the effect then should be considerable for low pressures, whilst it should be eliminated at high pressures.

It was only a question of testing the exactness of these inferences. The following are the results obtained by experiment:—

Experiment.	Outside the field.		Within a field of 7,200 units.	
Pressure in cubic centimetres.	Current in millliamperes.	Difference of potential in volts.	Current in milliamperes.	Difference of potential in volts.
0·607	5·86	976	3·91	9,787
32·446	4·66	2,815	2·75	5,857
74·610	2·79	4,669	2·04	4,719
76·020	3·50	5,544	2·05	6,919
114·310	2·33	8,058	1·44	8,097
155·51	2·16	8,731	1·27	9,487
230·1	1·42	12,028	0·74	12,539

At the very low pressure of 0·6 centimetre the potential difference becomes 10 times larger, but there is no variation worth mentioning at 3 kilogrammes pressure. I think I am justified in concluding from this that the magnetic field only affects the electrical discharge. The influence of the magnetic field, which is so great in a Geissler tube, depends, therefore, on the constitution of this tube, and the state of rarefaction of the gas enclosed in it; and no effect is produced by it on gases in free space.

This gave a valuable clue to the analysis of the very complex phenomena observed in the Geissler tubes. The similarity of the effects produced by a magnet, and the approach of a metallic conductor (or even a finger) lead me to suggest a new explanation of these phenomena. That there is a striking similarity may be gathered from an example. A tube containing fluoxide of silicium gave me the following results:—

Outside the field.		Near a mass of iron.		Within a field of 11,570 units.	
Current in milliamperes.	Diff. of potential in volts.	Current in milliamperes.	Diff. of potential in volts.	Current.	Diff. of potential.
1·500	2,434	1·16	3,185	·99	5,730

It is true that these effects vary with the nature of the gas, the shape of the tube, the pressure, &c., but they can nearly always be verified on tubes in the sensitive condition. The phenomenon is sufficiently general to admit of the action of the magnet being ascribed to a change in the electric capacity of the Geissler tubes; these tubes, therefore, are really condensers, and their illumination is the result of an oscillatory discharge, similar to that of a Leyden jar, of which the period T is a function of the capacity C of the jar, and of the coefficient L of self-induction of the conductor, assuming the resistance to be very small, for $T=\pi\sqrt{CL}$. A change in the capacity C will vary the vibratory condition of the gas, and would be the origin of the differences observed in the luminous phenomena in a strong magnetic field.

* From *Comptes Rendus.*

THE DISTRIBUTION OF LIGHTS IN TEXTILE FACTORIES.*

The lighting for textile industries is here considered, first, because there exists none other which has need of so powerful lights, and secondly, because it has been thoroughly studied in all its details, and in consequence the type of factories is nearly the same in all countries, all of which may, therefore, be compared among themselves. The rooms are large and they contain a certain number of similar machines. The walls and ceilings are assumed to be white. For spinning, the minimum number of lamps should be one 12-ampere arc for 180 to 200 square metres (say 230 square yards, or 15 yards × 15). The maximum for a 9 or 10 ampere arc should be 80 to 100 square metres (say 110 square yards, or $10\frac{1}{2} \times 10\frac{1}{2}$ yards). These areas are for high rooms and for spinning unbleached or clear coloured yarn. For weaving the minimum is a 12-ampere arc for 120 square metres (133 square yards, or $11\frac{1}{2}$ yards square). For white unbleached or clear colours, a good light is given with a 10-ampere arc over an area of 75 to 80 square metres (93 square yards, say $9\frac{1}{2}$ yards square). But for black, and especially for dark colours, which must be distinguished thread by thread, some workers are not satisfied unless 10-ampere arcs are placed 7 metres (23 feet) from each other, that is 49 square metres (59 square yards) for each lamp. In general it is not advantageous to employ lamps of less than 8 or 9 amperes; 10 amperes gives a good light for industrial use. When the rooms are small, or the lighting is not evenly divided, 6 amperes may be used. For blacks and dark colours twice the amount of light must in general be used as for white or light goods, and even then the eye will be fatigued. In weaving light goods by glow lamps, a 10-candle and even an 8-candle lamp may be used for lighting two looms for unbleached stuff, and, on the other hand, for colours, two 16-candle lamps to a loom; or, if it is rather long, two 20-candle lamps are needed. That is exceptional, but it may be said that in most cases one 16-candle lamp will suffice for two looms. For arc lighting it is not a question of the number of looms, but the area which has to be lighted; it is, in fact, a general illumination. The room must be lighted and all that is in it, without troubling about any particular machine or part on which the worker is occupied. Arc lamps obviously cannot well be employed in small rooms. For outside work in courtyards and the railway goods yards an excellent effect is produced by lamps of 15 amperes, placed at 12 metres (40ft.) high, or, in case of need, lamps of 12 amperes at 10 metres (33ft.) high; but it is not advisable to use less than this. These figures have been arrived at by practical experience in Belgium and Germany, and it is because they have been departed from in lighting the streets of Paris that the illumination there tires the eyes without making things properly visible. There is an unnecessary number of lamps placed too low, and of too feeble an intensity; moreover, this arrangement is more expensive.

THE RESIDUAL CHARGE OF CONDENSERS.†

BY M. E. BOUTY.

M. Bouty used two methods for measuring the residual charge. In the first the condenser, after having been charged for three or four hours, was short-circuited for a time θ and insulated for a time t, after which the charge liberated in this time was measured. In the second method, which was less direct but more exact, the condenser A to be tested was joined up in series with a subsidiary condenser B, and with a battery of small resistance and constant electromotive force E. The auxiliary condenser B was short-circuited for a time θ, after which the condenser A was allowed to charge B, in cascade, for a time t. If x and y are respectively the potentials of the condensers A and B, and if the capacity of A is K, while that of B is unity,

(i.) . . . . . $x+y=E$

(ii.) . . . . . $d(Kx)=dy$;

or since E is constant we have

$$dx+dy=0$$
$$K\,dx+x\,dK=dy.$$

From these we obtain

$$dK=\frac{K+1}{E-y}\,dy;$$

or since y corresponds with the residual charge, and is very small compared with E,

(iii.) . . . . . $dK=\frac{K+1}{E}\,dy.$

* Abstract from a communication to *L'Électricien.*

† Extract from *Comptes Rendus.*

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It is, then, sufficient to measure the charge $d\,y$, acquired by B in a short time, to deduce the increase, $d\,K$, of the capacity of A, and the increase, $E\,d\,K$, of the residual charge during the same time.

The times θ and t varied between 0·001 seconds and 4,000 seconds. For the longer intervals the commutations were made by hand, but for the other a torsions pendulum with mercury contacts was employed. A capillary electrometer was calibrated and used to measure the potentials.

The results of the experiments are briefly as follow :—

1. The residual charge liberated between the times θ and $\theta+t$ with the first method is identical with that absorbed by the same condenser in the second method between the same times θ and $\theta+t$.

2. The residual charge is proportional to the electromotive force of the battery used.

3. For a subdivided condenser the total residual charge is equal to the sum of the residual charges of the different parts, but these are not necessarily proportional to the capacities of the corresponding subdivisions.

4. For a Carpentier condenser, the residual charge R, liberated between the times θ and $\theta+t$, is given by the formula

$$R = A\left\{(t+\theta)^{0\cdot09} - \theta^{0\cdot09}\right\};$$

or between 0 and t,

$$R_t = A\,t^{0\cdot09},$$

where A is a constant.

5. The residual charge is small compared with the total charge. Taking the latter as unity, M. Bouty finds the following values for the residual charge of a Carpentier microfarad condenser :—

Value of t	·001	·01	·1	1	10	100	1000
„ „ R_t	·0180	·0222	·0273	·0336	·0412	·0507	·0624

These results are only exact if the battery employed has a small internal resistance. If a resistance is introduced into the circuit, or if a Latimer Clark cell of high resistance is used, the results are no longer precise. The batteries employed were very large, so as to have small resistance.

M. Bouty points out that errors arise in the determination of specific inductive capacity owing to uncertainties caused by residual absorption, and proposes to apply his results so as to obtain new and more accurate measurements. The investigation is also of value in determining the construction and mode of use of standards of capacity.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 1, 1890.

Fourth Avenue Railroad.—Additions to the rolling stock of the Fourth Avenue Railroad are now being made with rapidity. Four cars have been added within a short time, and others are being put on as fast as the batteries can be received from the factory. A few weeks will probably see a full electric service by accumulators on that line.

National Electric Light Association.—The meeting of this association at Cape May promises to be of considerable interest. A large number of electricians have expressed their intention of being present, and many interesting Papers are promised for the occasion. The last meeting, in Kansas City, was both well attended and important : but the present one, with its more available situation, will probably witness one of the largest gatherings of the Association yet recorded. At the same time the American Association for the Advancement of Science holds its meeting in Indianapolis ; and although the programme has not yet been definitely announced, it is understood that several electrical Papers will be read. In past years some very important electrical Papers have been read before that body ; although numerically the Association is not strong, it contains a large proportion of scientific men.

The Edison Company.—The re-organisation of the Edison Company is now formally announced. The change in management is a most complete and radical one, so that the organisation now is a unit—a great central office in New York, with branch district offices in various parts of the country. Previously it had been a rather loose combination of allied companies, and it is believed that the present change will result in greatly increased prosperity from the more business-like methods that will be followed. At the same time there are not a few grumblers among the electricians who are left out in the cold by the disorganisation of minor companies.

The Government Postal Telegraph Scheme.—Having been from time to time proposed, this is again before Congress for consideration. It seems to be improbable that anything will be done with the more or less vague plans which have been formed. We are hardly ready here for such a radical change, especially as most people who use the telegraph do not fancy the idea of a telegraph service which changes its organisation entirely at each change of administration. There is a pretty firmly rooted idea that a Government service, while it might be somewhat cheaper than the present one, would not be anywhere nearly as satisfactory ; and this popular prejudice is, in all probability, true.

Electric Tramways in Brooklyn.—There is a proposition now before the authorities to permit the use of the overhead trolley system for electric roads throughout the city of Brooklyn. The matter is being rather violently discussed in the newspapers, and it is not at all improbable that, after the successful experience of Boston with the overhead wires, Brooklyn may be induced to try it. It certainly would be a great victory for electric traction, if it is possible to break down the barriers of prejudice which have thus far interfered seriously with electrical progress in large cities. We have now something like 1,700 miles of electric roads in this country, and only a small portion of it is in the cities where rapid transit is most desirable. If the overhead system were successfully tried in Brooklyn—although we can hardly venture to hope it, in view of the legislative stupidity which marks the government of New York—it might be that at some future time we should have rapid transit on Manhattan Island.

CORRESPONDENCE.

THE EFFECT OF CIRCULAR MAGNETISATION ON THE RESISTANCE OF IRON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : Will you kindly allow me to correct an error in my article on the above subject? The mode of conducting the experiment there described was, through a slip of memory, incorrectly stated. The time during which the battery key was kept down at each trial of the balance was not 10 seconds but only a fraction of a second. When I wrote the article I had not my Paper, "The Influence of Stress, &c.," *Phil. Trans.*, 1883, at hand, and I now find in it (p. 162) an account of the experiment, which, after having altered it in some unessential particulars, I send : "The sliding-piece was shifted until the double process of closing and *immediately* afterwards opening the battery circuit produced no sensible deflection. In this way the resistance ratio of the iron and platinum was approximately determined. The sliding-piece was then shifted a few divisions, first to one side of the apparent position of balance and afterwards an equal number of divisions to the other side, and the deflections produced by the double closing and opening process were noted. Thus, with three B A units in the battery circuit, the balancing point *seemed* to be 55 divisions to the right of the zero of the platinum silver wire ; on moving the sliding-piece first to 75 and afterwards to 35, deflections of 5 to the left of the galvanometer scale, and 6 to the right were respectively obtained. A left deflection indicated that the sliding-piece should be moved to the left in order to get a true balance, thus the true balancing point would be $35 + \frac{(6-\frac{1}{4})\,40}{11} = 56$ nearly." (The $\frac{1}{4}$ comes in because the impulsive effects on the galvanometer, arising from self-induction at the instants of closing and opening the circuit, evidently do not *quite* neutralise each other.)

In a similar manner the other readings recorded in the article were made.

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Such a plan as the above is open to objection, and was only resorted to in sheer desperation of getting rid of thermal effects. It is true that the heating effect on the *resistance* of the iron was nearly the same as for the platinum, and that consequently the *real* resistance-ratio of the two metals would be but little affected; but this does not prevent error which arises from the fact that at the *junction* of the iron and platinum a *Peltier-effect* is produced by the passage of the current.

For currents of from 0·1 to 0·5 amperes I found it sufficient, after well coating them with shellac varnish, to immerse the platinum and iron wires in a large trough of water or oil, and in this case the current can be kept flowing long enough to allow the effects of self-induction to subside, and yet not to produce any very material error from heating.

I have spent a very considerable time over these experiments on circular magnetisation, and at the outset thought that I could detect a *true* increase of resistance from this cause; but the more the investigation progressed, the more did I become convinced that if there is a true alteration of resistance due to circular magnetisation at all, it is likely to prove too minute to be detected with any certainty.—Yours, &c.,

HERBERT TOMLINSON.

CONTINUOUS-CURRENT TRANSFORMER AT THE CHELSEA COMPANY'S WORKS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The account of the above, which appeared in your issue of the 1st inst., would lead the reader to suppose that the machine has only been subjected to "testing."

Will you, therefore, allow me to add that it has been in constant use for at least three months, during which time it has been used for augmenting the supply during the period of maximum demand.

Its load of 32 kilowatts in the secondary has always been easily rendered, and it has never given the slightest trouble, or required other attention than the usual oiling.

It is absolutely self regulating, maintaining a similar E.M.F. to that of the discharge circuit, whatever be the variation (if any) of the total output in watts.

Your description misstates the form of armature, which is of the "ring" form; the reason for the adoption of which being the convenience of winding and maintenance of insulation between the primary and the secondary coils.

There can be little doubt, however, that the "drum" type would give better efficiency; and probably future machines of this class will be so constructed.—Yours, &c.,

August 11, 1890. FRANK KING.

THE LIGHTING OF LONDON THEATRES BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read with considerable interest in your issue of August 1st, Mr. De Segundo's article about "The Lighting of London Theatres by Electricity;" and although I am somewhat late, I beg to ask you to rectify the figures relating to the cost of the installation at the Lyric Theatre. M. De Segundo writes:—"I may just mention, without comment, that this installation, as designed by M. Sechehaye, cost £19,000."

The real cost, including all the expensive fittings, £2,500 for storage batteries, and also one year's maintenance, does not exceed £8,000, which is not excessive if the extent of the installation (over 3,000 16-candle power lights and 12 arc lights) be taken into consideration.—Yours, &c.

EM. SECHEHAYE.

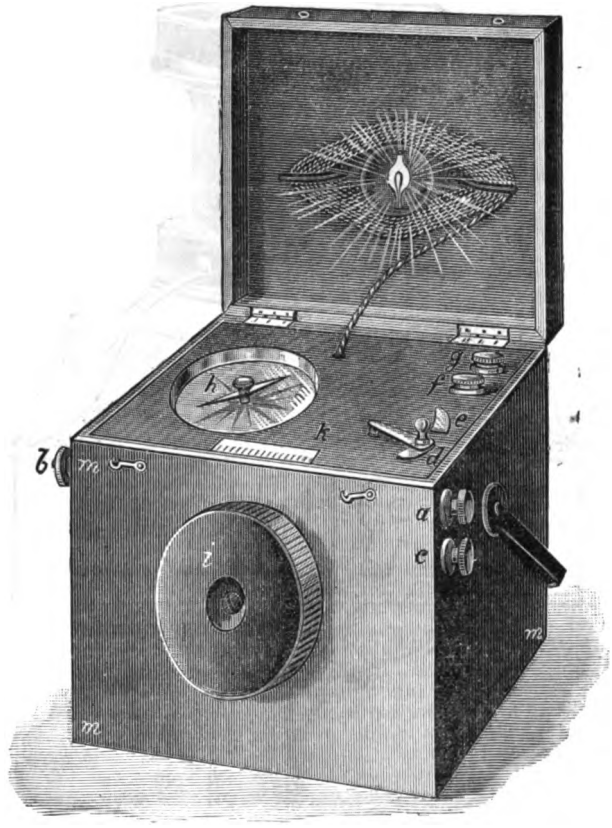
11, Queen's-terrace, St. John's Wood, N.W.,
August 13, 1890.

Annual Excursion.—The contract department of Messrs. Woodhouse and Rawson held their annual excursion on Saturday last, August 2nd, when a most enjoyable day was spent by a number of the *employés* at Brighton.

THE CENTRAL STATION COMPANION.

One of the chief difficulties which an electrical engineer has to contend with in central station work is the large number and inconvenience of instruments required for practical testing. This evil is growing daily, and any invention which tends to lessen it will be welcomed by the supply companies. A combination instrument called the "Central Station Companion" has just been invented by Mr. H. J. Dowsing and Mr. A. A. Day, the leading features of which are its compact form and simple arrangement, qualities which are greatly to be commended. Various combinations have been made, but the present form is the one which affords a great variety of uses in a remarkably small compass.

The "Central Station Companion," as usually made, is of the following dimensions, viz., 6in. by 8in. by 4in., and contains, 1, an ordinary detector or galvanometer; 2, a Wheatstone bridge to measure from ·05 to 50 ohms; 3, a standard ohm; 4, a variable resistance or rheostat; 5, a set of four small accumulators for giving a light when testing; 6, necessary switches, connections, contacts, &c. If required, a 10-ohm standard coil can be inserted to increase the readings tenfold. An essential feature of the "Central Station Companion" is its simplicity. Any workman can use it, and as there are no loose keys, complicated coils, or calculations to make, mistakes cannot occur.



(*a* and *b*) Bridge terminals for resistances (switch on *d*) (*b* and *c*) Detector terminals; (*d*) Contact for switch when using detector; (*e*) Contact for switch when using bridge; (*f*) Battery key for use with bridge or detector; (*g*) Galvanometer key for use with bridge; (*h*) Galvanometer; (*i*) Knob for adjusting bridge resistances; (*k*) Scale for reading resistance in ohms; (*l*) Incandescent lamp with connecting wires; (*m*) Case containing batteries, &c.

To use as a detector, the ends of the circuit must be connected to the two end terminals, and the key pressed, when the battery and galvanometer are put into circuit. To use as Wheatstone bridge, all that has to be done is to insert the resistance to be measured between two of the terminals and turn the knob in front (which inserts more or less resistance) while pressing keys until there is no deflection in the galvanometer. Then read the actual resistance from the scale. As above stated, there are no calculations required, and the resistance in ohms is read off direct. With a little adaptation the instrument can be used as a potentiometer, or for comparison of potentials by Poggendorff's method.

The incandescent lamp is a useful addition to the testing set and makes the instrument useful as a portable lamp, and the battery can readily be charged at any of the stations where low-tension continuous-currents are in use. If, however, it is preferred, a special form of Leclanché can be fitted, which will run a small lamp for a few minutes, giving ample time to make intermittent tests. It is an important point in connection with this testing apparatus that it can be made to measure higher or lower resistances as required for

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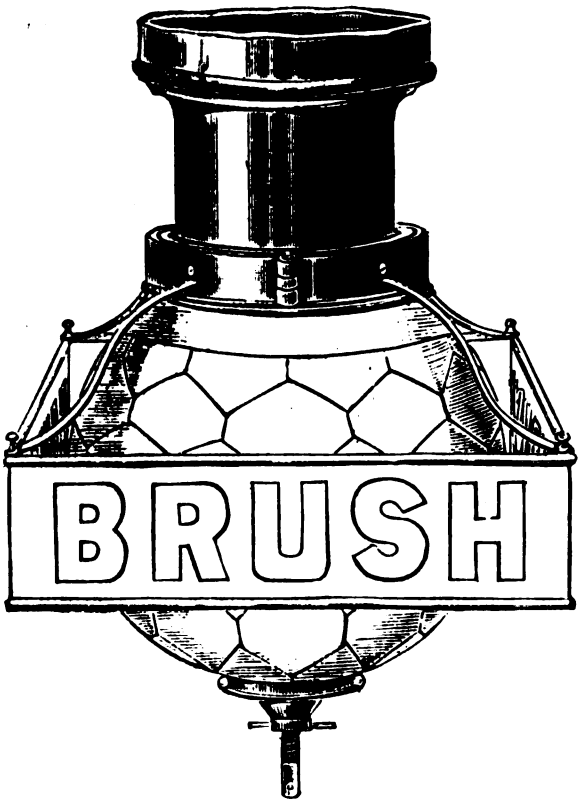
special purposes. The scales can be given a large range of reading at any desired point, so that accuracy may be assured. Perhaps the greatest arguments in favour of the "Companion," beyond its compactness and portability, is the low price at which it can be made. One of the ordinary size can be obtained at about half the cost of the cheapest form of Wheatstone bridge. The "Companion" is made by Messrs. Day and Co., of 60, Queen Victoria-street, who will give any further information required.

TRADE NOTES AND NOTICES.

THE DUBLIN SCIENCE AND ART BUILDINGS.—Four firms were invited to tender for lighting the new Science and Art buildings in Dublin by electricity—viz., Messrs. Siemens Brothers and Co., Messrs. Johnson and Phillips, Messrs. Edmundson and Co., and the Brush Company; and tenders were received from the three first named. Messrs. Edmundson's tender for £8,375, being the lowest, was accepted. The contract with them contains no stipulation as to giving a preference to any firm.

WADE'S PATENT ARC LAMP TABLETS.—We have received from the Birmingham Street Lamp Company an illustrated circular showing the various styles of their arc lamp tablets, one of which is shown in the accompanying figure. These are unquestionably very effective, and electric light contractors should send for particulars to the Company.



DISSOLUTION OF PARTNERSHIP.—The partnership heretofore existing between John Shaw, Thomas Connolly, and William Speakman Brown, trading as electrical engineers at the Newton Electrical Works, Newton Heath, Manchester, is dissolved. It will be remembered that the business of Messrs. Shaw and Connolly was recently acquired by the International Okonite Company (Limited).

REMOVAL NOTICE.—We are informed that Messrs. P. Walters and Co., telegraph engineers and contractors, have removed from 217, Latimer-road, Notting Hill, to 249 and 251, Kensal-road, London, W.

LUNDY CABLE COMPANY, LIMITED (IN LIQUIDATION).—Tenders are invited for the whole of the cable, land lines and plant belonging to the above Company, comprising about eight nautical miles of the main cable between Lundy and Hartland Point, three nautical miles of shore ends, three miles of spare cable, five miles of land line, a wrought-iron circular cable tank, paying-out and picking-up machinery, buoys, ropes, tackle, &c. Tenders are to be forwarded to the liquidator, Mr. Herbert J. Goss, F.C.A., 59, Wind-street, Swansea, on or before August 21st. Further particulars will be found in our advertising columns.

MESSRS. WOODHOUSE AND RAWSON UNITED (LIMITED).—We have received an intimation that this Company have taken over the works and business of Messrs. King, Masterman, and Terry, iron and steel founders and boiler makers, of the Union Foundry, Kidsgrove, Staffs. These old-established engineering works are situated in the heart of the Staffordshire coal and iron district, and possess direct railway and canal communication with all parts of the kingdom. Messrs. Woodhouse and Rawson United (Limited) announce that they are now in a position to manufacture and supply complete plant for electric lighting stations, including engines, boilers, dynamos, accumulators, lamps, and all other accessories and fittings. Messrs. C. E. Masterman and S. H. Terry will undertake the management of the works. Messrs. Woodhouse and Rawson United (Limited) have also taken West End offices at 16, Great George-street, Westminster, which will be under the management of Mr. H. Sampson King.

MESSRS. DRAKE AND GORHAM.—We have received from this firm price lists of the Cardew Earthing Device and of the Cardew Patent Voltmeter.

LEGAL INTELLIGENCE.

Luther Hanson and Co. (Limited) v. Butler and Co.

This case was heard at the Yorkshire Summer Assizes. Mr. E. Tinda Atkinson, Q.C., and Mr. Waugh represented the plaintiff, the official liquidator of Messrs. Luther Hanson and Co. (Limited), electrical engineers, Halifax; and Mr. Lockwood, Q.C., and Mr. Kershaw were for the defendants, Messrs. James Butler and Co., engineers and tool-makers, Halifax.

The plaintiff sought to recover £115, the value of work done.

It appeared from the opening statement of Mr. ATKINSON, that in January, 1889, plaintiff entered into a contract with defendants to erect an electrical installation at their works. The plant was put down, but was a failure, as the lamps continually went out. They were what is known as the Luther arc lamps. The dynamos were worked by the engine working the rest of the machinery on the premises, and the plaintiff alleged that the failure of the lamps was owing to the irregularity with which the engine worked, and not to any defects in the lamps.

The defence was that the lamps were of faulty construction, and that they would not work satisfactorily, whatever the motive power was.

His LORDSHIP remarked that it was evident scientific questions would arise, and he did not feel disposed to deal with them.

Ultimately it was agreed that Mr. J. N. Shoolbred, London, consulting electrical engineer to the Bradford Corporation, &c., should be requested to examine the plant and report upon it; and his Lordship adjourned the hearing of the case until the receipt of the report.

WOODHOUSE AND RAWSON ELECTRIC SUPPLY COMPANY OF GREAT BRITAIN (LIMITED).—A petition for the winding up of this Company presented by G. H. Allfrey, was in the list on Saturday for hearing before Mr. Justice Stirling. It was ordered to stand over till next sittings, with leave to cross-examine in the meantime.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

July 21, 1890.

11,402. L. PFINGST. London. Improvements in couplings for electric railway vehicles.

July 22, 1890.

11,440. L. MANSFIELD. London. Electric railways.

11,465. M. W. DEWEY. London. Improvements relating to riveting by the aid of electricity.

11,466. T. M. FOOTE. London. An improved electro-magnetic friction clutch.

11,480. E. THOMSON. London. Improvements in dynamo-electric machines and electro-motors.

July 23, 1890.

11,490. F. H. ROYCE. Manchester. Improvements in armatures for electrical apparatus, such as dynamos, motors, and transformers.

11,495. A. HEALD. London. Improvements in appliances for use with gas lamps for producing light by incandescence.

11,499. A. E. WADLEY. Gloucester. Improvements in dynamo-electric machines.

11,520. J. P. BAYLY. London. An improved electric bath brush. (Robert Williams and Wilbur Shook, United States.)

July 24, 1890.

11,577. J. W. NEWALL. London. An improved method of propelling carriages by means of electric motors.

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11,601. A. H. Cowles. London. A process for obtaining metals in molten condition from their fused oxides by electrical action (F. W. Matthiessen, United States).

July 25, 1890.

11,653. W. E. Keys. Manchester. Improvements in and connected with the electric propulsion of vehicles on railways and tramways (Jean Jacques Heilmann, France).

11,657. W. E. Gibbs. Liverpool. Improvements in electric dental pluggers.

11,680. M. G. Farmer. London. An improved apparatus for producing sheets of metal by electro-deposition.

July 26, 1890.

11,699. G. Mahusen. London. Process for obtaining chlorine and bromine by the aid of electricity.

11,720. R. J. Jones and G. Worrall, on behalf of Woodhouse and Rawson United (Limited). London. Improvements in connection with electrical fuses.

11,737. F. W. Allchin and J. Lea. London. Improvements in posts or pedestals for electric arc lamps, in the arrangement and mechanism of arc regulators, in guide apparatus for carbon holders, and in apparatus for automatically cutting an arc lamp out of circuit.

July 28, 1890.

11,788. S. P. Parmly. London. Improvements in electric arc lamps.

11,816. M. M. Stainer. Southampton. The electric furniture polish reviver.

11,817. F. H. Aldrich. London. Improvements in electric light fixtures.

11,842. G. L. Anders and J. R. Shearer. London. Improvements in the deposition of metal by electrolysis.

11,862. W. E. Ayrton and T. Mather. London. Improvements in electrostatic measuring instruments.

11,863. W. W. Strode and C. G. Gill. London. Improvements in electric switches.

11,883. T. Tomlinson. London. Improvements in the distribution of electricity, and in the apparatus employed therein.

July 30, 1890.

11,919. T. Legay and L. Legay. London. Improvements in the manufacture of lead wire, suitable for electrodes and for other purposes, and in electrodes made of such wire.

July 31, 1890.

11,950. C. Hamilton. Glasgow. Improvements in gas, electric, and other globe or shade holders.

11,962. E. W. Lancaster. Birmingham. Improvements in electric bells, bases, covers, and parts.

12,009. J. S. Ross. London. Improvements in electric indicators and in bells, applicable also to other purposes.

August 1, 1890.

12,053. J. Hinks and J. Hinks and Son. Birmingham. Improvements in the suspending mechanism of chandeliers, gasaliers, electroliers, and other similar suspended bodies.

12,094. R. Morris. London. An electric fuse for firing guns.

August 5, 1890.

12,171. S. E. Mower. London. Improvements in electric motor mechanism.

12,188. W. P. Thebrman. Salford, Lancashire. Improvements in electrical switches.

12,209. H. René. Paris. Improvements in electric meters. (E. Meylan and W. Rechniewski. France.)

12,221. H. H. Lake. London. An improved apparatus for the measurement of electrical energy. (E. Merton, United States.)

12,225. J. W. Easton. London. Improvement in commutators for dynamo-electric machines.

12,231. W. W. Dail. London. Commutators for electrical machines.

12,244. A. V. Newton. London. Improvements in sockets for electrical lamps (Alfred Swan, United States).

12,247. H. H. Lake. London. Improvements in and relating to electric lamps or lighting apparatus (G. C. Pyle, United States).

August 6, 1890.

12,330. G. E. Gourand. London. Improvements in thermo-electric batteries (E. N. Dickerson, United States).

August 7, 1890.

12,337. C. Herzog. London. The indestructible electric filament used for incandescent electric light.

12,352. A. H. Bagnold. Rochester. Making electric contacts for ringing electric bells, and other purposes.

SPECIFICATIONS PUBLISHED.

1889.

11,242. Siemens Bros. and Co. (Siemens and Halske). Dynamo-electric, etc. machines. (Price 11d.)

11,501. Ward and Gregory. Electric fuses and detonators. (Price 8d.)

12,982. Barton. Electrical switches. (Price 6d.)

13,371. Parker and Fairall. Telegraphic apparatus. (Price 8d.)

13,580. Redfern. Electric body belt. (Price 6d.)

13,675. Langdon. Electrically lighting railway trains. (Price 8d.)

13,859. Houghton. Regulator for electric lighting. (Price 6d.)

17,276. G. and W. Donovan. Incandescent electric lamps, &c. (Price 8d.)

17,763. Rawson and White. Electrical switch-boards, &c. (Price 8d.)

17,762. Rawson and White. Electrical switches. (Price 6d.)

1890.

4,191. Farrall. Generating heat, &c., by electricity. (Price 8d.)

4,660. Butterfield and Mitchell. Heating and cooking by electricity. (Price 8d.)

5,764. Thompson (Berne and another). Electrical intercommunication. (Price 6d.)

6,124. Munsie. Underground electric conduits. (Price 8d.)

7,003. Duncan and Carpenter. Electric motors. (Price 8d.)

7,853. Thompson (Coffin). Welding metals electrically. (Price 8d.)

7,867. Lake (The Giant Electric Motor Company). Electric motors. (Price 8d.)

8,567. Cobb. Conductors, &c. (Price 8d.)

8,578. Johnson (Hering). Electric accumulators. (Price 8d.)

8,703. Thompson (Coffin). Electric welding. (Price 6d.)

8,730. Miner. Electric soldering-irons. (Price 6d.)

9,125. Kingsbury (The Western Electric Company). Telephonic apparatus. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Chili Telephone Company (Limited).

The first ordinary general meeting of this Company was held at Winchester House, Great Winchester-street, on Friday, the 8th inst., under the presidency of Mr. R. Raynsford Jackson.

The SECRETARY (Mr. Edmund Petley) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said the report dealt so fully with the business of the Company during the period over which the accounts extended, that it was quite unnecessary for him to occupy their time at any great length. They must have all, doubtless, read the prospectus of the Company, and they would have seen that the Directors had felt pretty confident that there would be no difficulty whatever in paying from the commencement a dividend at the rate of 6 per cent. As they would see by the report the dividend recommended amounted to only 2s. 6d. per share, which was equal to 5 per cent. Many of them would, no doubt, be inclined to ask the reason why it was to be 5 instead of 6 per cent. He would endeavour briefly to satisfy the anxieties of the shareholders upon this point. In the first place, when the prospectus was issued the rate of exchange was 26d. It had fallen to 24d., and the average rate of exchange during the eleven months over which the accounts extended was 25¼d. If the rate had continued at 26d. the earnings of the Company would have been between £900 and £1,000 more, and the dividend anticipated by the Directors would have been realised. There had been, moreover, another difficulty which the Board had had to contend against, and which had had the influence of preventing the General Manager in Chili from controlling the management of the Company until the middle of the last month of their financial year. It turned out that there was an unregistered body of shareholders in the West Coast Telephone Company, which was the vendor company, in Chili. Not having had their shares registered they were left in ignorance of the proceedings of the West Coast Company. They suddenly learned that the property in which they were interested had been sold, and they imagined that the sale price was over and above the liabilities of the Company, and that, therefore, they were entitled to receive a large sum. They were, however, altogether wrong in the view which they took of their position, because the West Coast Company's system having been sold upon condition that that Company should meet all its own liabilities, all that those shareholders were interested in was the amount remaining to the West Coast Company after those liabilities were met, and that was a small amount indeed. They, however, thought that they could protect their interests by preventing the legal registration of the transfer of the West Coast Company's telephonic enterprise to the Chili Telephone Company. The transfer had been completed, but the representatives of the dissentient shareholders asked for an injunction in the Chilian Courts to prevent the registration of the transfer until their claims were satisfied. The result was that the management of the Chili Telephone Company remained in the hands of the vendor Company until the middle of the last month of the year, when arrangements were made with the West Coast Company to appoint our general manager as their general manager, before which they had had little control, direct or indirect, over the affairs of the Company. Happily, their general manager had now a recognised position, which enabled him to look after the Company's affairs, to introduce economy, to improve the service, and otherwise develop and promote the interests of the Company. There had been an increase during the year of 33 per cent. in the number of subscribers, notwithstanding all the difficulties that the management had had to face, and he thought that they might anticipate a still larger increase in the current year, because not only had the adverse circumstances to which he had referred

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been practically put on one side, but in addition they had purchased for £36,000 the only rival of the Company there was in Chili—the National Telephone Company of Chili. That Company was under the control principally of natives, who had considerable power and influence in Santiago and Valparaiso. They had been hostile to this Company, and they had co-operated with the dissentient shareholders so that the two together would have made it difficult for the Company to carry on its business satisfactorily. But owing to the purchase of the National Telephone Company of Chili, and to the fact that the dissentient shareholders had thereby been weakened and might speedily be settled with, he thought he might hold out to the shareholders the assured prospect that the Company would realise all the anticipations indulged in by the Board, and that they might congratulate themselves on the possession of a property of great intrinsic value. He concluded by moving—

"*That the report of the Directors and statement of accounts to the 31st March, 1890, now presented to this meeting, be approved and adopted.*"

Mr. THOMAS GREENWOOD seconded the motion, which was agreed to unanimously without discussion.

The CHAIRMAN next moved—

"*That a dividend of 2s. 6d. per share, as recommended by the Directors, be and is hereby declared, and that the same be payable at the Company's bankers on and after the 9th inst., free of income-tax.*"

The Hon. F. ERNEST ALLSOPP seconded the motion, which was agreed to *nem. con.*

The CHAIRMAN then proposed the re-election of Mr. Thomas Greenwood to his seat at the Board, and said that owing to the confidence of the other Directors and of the vendor in that gentleman, they had entrusted him with carrying out delicate negotiations, which he had managed with great tact, skill, and success.

Mr. VENABLES seconded the motion, which was carried unanimously.

Mr. GREENWOOD having acknowledged his re-election,

The CHAIRMAN proposed, and Mr. H. W. BARBER seconded, the re-election of the Hon. F. Ernest Allsopp to his seat at the Board, which was also agreed to *nem. con.*

On the motion of Mr. E. E. VENABLES, seconded by Mr. H. W. BARBER, Mr. Thomas A. Welton was reappointed auditor.

On the motion of Mr. ALEXANDER HENDERSON, seconded by Mr. WHITTET, a vote of thanks was accorded to the Chairman and Directors.

The resolution having been carried unanimously,

The CHAIRMAN acknowledged the compliment, and the proceedings terminated.

City and South London Railway Company (Limited).

The 12th ordinary general meeting of the proprietors in this Company was held at Winchester House, Old Broad-street, on the 12th inst., under the presidency of Mr. Charles Grey Mott.

The SECRETARY (Mr. H. H. M. Smith) having read the notice convening the meeting,

The CHAIRMAN proposed the adoption of the report and accounts. He reminded them that at the last meeting one of the tunnels was in an incomplete state. They were then, however, steadily driving it through the stratum of wet gravel at Stockwell; and he was happy to say that this tunnel was now completed, and no mishap had occurred. The whole of the tunnels were now finished, and he thought they might accord their best thanks to the engineers and contractors for the successful way in which they had carried out an exceptionally difficult work. He believed there was hardly on record anywhere so great a length of tunnel where there had been so little loss of life or accidents connected with it as had happened in their own case. He was glad to say that the completion of the tunnels had been followed by the completion of the permanent way, the rails being all laid. The electric main cable for conducting the electricity was also laid through both tunnels, and the service conductor which conducted the electricity to the locomotives was also laid through both tunnels. The two lifts had been a much longer period in being completed than they anticipated, or that Sir William Armstrong's firm had given them to understand would be taken. This had caused some delay in the completion of the work, because until the lifts were finished they could not proceed with many of the works connected with the stations and bridges. He was glad to say that the lifts were now making very satisfactory progress, and he hoped that it would not be long before they would see the works finally executed. The stations below were all practically finished, and above they were very nearly so. They had hoped to light the stations with electricity taken from the ordinary conductors from the supply power; but it was found that there were certain fluctuations of the light in taking power in this way, and also that a considerable amount of power was consumed which they were very unwilling for a moment to take from the propelling power which they wanted, and which after all was a most important question. For the moment, therefore, they had decided to light the stations with gas, but there was no doubt that ultimately they would be lighted with electricity. The signalling arrangements throughout the whole of the tunnels were approaching completion. At the depôt there were three hydraulic engines—that was, engines for compressing the water which drove and worked the lifts. Those engines were completed, and everything was in good order. There were three vertical engines of great power for driving the dynamos to produce the electric current. One of the engines had been working with one dynamo very satisfactorily indeed, and it answered all their expectations. A second vertical engine and dynamo were also ready, and would, he believed, be working for the first time that day. The third vertical engine, which was held as a reserve power, was very nearly completed. The engine and carriage sheds had been roofed in He was sorry the line was not open yet, as he had hoped. An engine and stock had run the whole length of the line with electrical power at a speed greater than was required for the service of the line. They had no reason to doubt now that the railway would be opened in a very short time. They were now busy engaging and arranging for the staff for working the line. Of course being, perfectly new to the work, it would be necessary that they should have some time in order to get acquainted with their duties; and, therefore, it would be necessary that the line should be run for a short time before it was open to the public, so that they might have no breakdown afterwards, and that everything might be in perfect order. They were taking every precaution to secure this object. He hoped that at the end of next month they would be able to open the line, but they must take it from him that that was his hope; for, after all their disappointments, he was very loth to predict. They could, however, judge for themselves from the particulars he had given that they were not very far off the opening now. The Bill to which they gave their assent for the extension of the line to Clapham had received the royal assent, and the name of the Company had been changed to its present title—the City and South London Railway Company. They proposed at a special meeting that day to create in the ordinary way, as most railway companies did, the capital authorised under that Act, but they had no intention of immediately going on with the extension to Clapham until they saw the line in working order. The Bill for authorising the Central London Railway Company, to which he alluded at the last meeting, and in which it was proposed to make a junction with this Company, and which would have been practically unworkable with their line altogether, had been thrown out by the House of Lords after a long inquiry. He was inclined to think that this was not an unwise proceeding on the part of the House of Lords. The Bill was not conceived on the lines of this Company or on lines which would have made it a profitable undertaking to its shareholders. It might and probably would be re-introduced in a better form, and if they could arrange to work with it they would be very glad to do so. There were certain points as to which they would have to get the shareholders' assent, and which would give them more control of the City traffic than they had at present, and at

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The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
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comparatively small cost to their own line. Up to the present time they had spent some £666,000, but they had some valuable land as an asset against that amount. They had kept practically very close to their original estimates as to the cost of the line, and it was upon that cost that the future earnings and the future dividends upon the City underground railways must depend. The capital cost of any underground line in London must be kept within definite limits. The Metropolitan and District companies had an enormous traffic, and they saw what a very poor return those companies gave to their shareholders, notwithstanding that they had magnificent traffics. This was a warning which should never be forgotten by the shareholders, and in any extension they must recognise the fact that the cost of the line must be kept within certain known and defined limits if there was to be a proper return for their money.

Mr. SAMPSON HANBURY seconded the resolution, which was at once unanimously adopted.

On the motion of the CHAIRMAN, seconded by Mr. HANBURY, a resolution was passed, authorising the conversion of the existing share capital of the Company into Consolidated Stock.

The CHAIRMAN said that they did not propose to act upon this resolution at once, as it would be better that the share capital should be more completely issued at first. It would, however, be more convenient hereafter to carry out the conversion.

Resolutions were afterwards passed, creating, under the City and South London Railway Act, 1890, 20,000 new ordinary shares of £10 each, and authorising the Directors to raise by borrowing the sum of £50,000, and for that purpose to create and issue Mortgage Debentures or Debenture Stock.

On the motion of Mr. S. G. SHEPPARD, seconded by Mr. LOVELL, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN having briefly responded, the proceedings terminated.

Liverpool Overhead Railway Company (Limited).

The fourth half-yearly meeting of the shareholders of this Company was held on Tuesday in Liverpool; Sir Wm. B. Forwood presided.

The CHAIRMAN, in moving the adoption of the report and balance-sheet, desired to explain in a few words the position of the undertaking. The works were not actually commenced till October last, and he regretted to say that the progress made was not so rapid as the contractors had led them to expect. This did not arise out of any difficulty in the construction of the overhead railway itself, that being a very simple matter indeed; but it arose from the automatic machinery which the contractors employed with the view to economy not being in the perfect working order which he had believed. He was glad to say, however, that all the difficulties connected therewith had since been overcome, and the machinery for turning out and drilling the plates was now working perfectly, and the work was being proceeded with as quickly as might be expected. They were now turning out nearly two spans per day, and, if they continued at this rate the line would be completed in 12 or 13 months. Difficulties were, however, always incidental to works where machinery was employed, and therefore they must not be too sanguine that the work would be finished in the time named. Comparing this railway with what he had seen of American overhead railways, this would be the best-looking overhead railway he had seen. As to the equipment of the line, they had not yet taken any steps, but, as previously indicated to the shareholders, electricity had been adopted as the propelling power. The progress in this as a motor was such that they had been advised by their engineer to postpone deciding upon the precise system until the last moment.

The report and balance-sheet were adopted, and a vote of thanks to the Chairman terminated the proceedings.

National Association for the Exemption of Machinery from Rating.

The annual general meeting was held at the Westminster Palace Hotel on Wednesday. Among those present were A. B. Winterbotham, Esq., M.P., William Mather, Esq., M.P., R. G. Mowbray, Esq., M.P., and many leading manufacturers.

The Report of the Executive Committee stated that they had to congratulate the members of the society on the great success which has so far attended its work, inasmuch that although it was found impossible to secure the presence of forty members of the House of Commons when the matter came up for discussion in the Session of 1889, the Bill for the Exemption of Machinery from Rating was read a second time on April 16th last, after a long debate, by a majority of 152 in a House of 330 members. It was stated that 169 petitions, containing the names of 21,149 persons, had been presented to the House of Commons in favour of the Bill. These petitions emanated from all classes, and included boards of guardians, corporations, chambers of commerce, trade unions, and large numbers of mechanics; while the petitions in opposition to the Bill contained only 348 names, almost entirely from Poor-law officials. Mr. Winterbotham and other members of Parliament explained the causes which had led to the failure of almost every private members' Bill in the past Session, and had prevented the passing of the Bill promoted by the society. It was resolved that the measure should again be introduced in the House of Commons in the next Session.

Votes of thanks were passed to the numerous members of Parliament who have supported the Bill, and to the Press for its almost unanimous advocacy of the objects of the society.

The report and accounts for the past year were adopted, and it was announced that the Court of Appeal had confirmed the decision of the Queen's Bench in the Chard case as to the rating of machinery, and there was an unanimous expression of opinion that a further appeal should be made to the House of Lords.

A vote of thanks was unanimously given to Mr. Humphreys Davies, the hon. secretary, for his valuable services.

CITY NOTES, &c.

BIRMINGHAM TRAMWAY COMPANY (LIMITED).—At the annual meeting of this Company on Thursday, the Chairman said that the year's operations had been very prosperous. The opening of the electric line in the Bristol-road had been demonstrated to be a scientific and mechanical success. What now remained was to see whether it could be worked with economy. Steam traction cost 3d. per mile; he believed the cost of electric traction would not be far from that sum.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 8th amounted to £4,863.

GRANGE SYNDICATE (LIMITED).—This syndicate has been registered with a capital of £2,000, in £5 shares, to develop and experiment upon Groth's electric tanning system, in conjunction with the patentee, upon terms of an agreement with Mr. L. A. Groth.

SHEFFIELD TELEPHONE EXCHANGE AND ELECTRIC LIGHT COMPANY (LIMITED).—The *London Gazette* of the 12th inst. states that at an extraordinary general meeting of the Sheffield Telephone Exchange and Electric Light Company (Limited), duly convened and held at the offices of the Company, Commercial-street, Sheffield, on July 11, the subjoined resolutions were passed, and at a subsequent extraordinary general meeting of the Company held at the same place on July 29th, they were duly confirmed:—"That it is desirable to reconstruct the Company, and, accordingly, that the Company be wound up voluntarily, and that Thomas George Shuttleworth, of Sheffield, chartered accountant, and William Johnson, of Sheffield, the secretary of the Company, be, and they are hereby, appointed liquidators for the purpose of such winding-up."

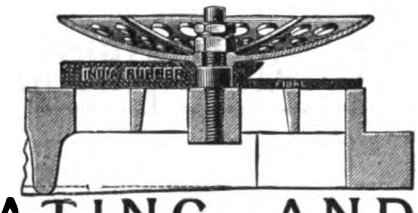
SOUTHEND TRAMWAY.—The tramway earned £6. 4s. 6d. on Saturday, the opening day; £25. 12s. 3d. on Monday; and £23. 4s. 7d. on Tuesday.

STOCK EXCHANGE.—Application has been made to the committee to appoint a settling day in and to grant a quotation to Elmore's Wire Manufacturing Company (Limited) ordinary shares; and to allow the Electric Construction Corporation (Limited) shares to be quoted in the official list.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 8, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,761.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 26th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 6.		Price Wednesday, Aug. 13.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 13.	
£								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
1,381,380	Stock	15/0	Anglo-American	49⅛	50⅛	49⅛	50⅛	5 8 11	Jan., Apr., July, Oct.	50	49⅞
2,809,310	Stock	30/0	Do. Preferred	85	86	85	86	6 7 11	" " " "	86	85
2,809,310	Stock	..	Do. Deferred	14⅛	14½	13⅝	14½	..	.. ..	13⅞	13⅛
25,000	£100	4%	African Direct, 4 per Cent. Debentures	97	100	97	100	4 0 0	January and July	..	..
130,000	10	3/0	Brazilian Submarine	11⅛	12	11⅝	12⅛	5 6 1	Mar., June, Oct., Dec.	12⅛	11⅛
69,200	100	5%	Do. 5 per Cent. Bonds	100	102	100	102	4 18 0	January and July	100⅛	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	..	..
..	$100	..	Commercial Cables	103	105	103	105	..	.. ..	103½	..
16,000	£10	9/0	Cuba Submarine	12⅝	13⅛	12⅝	13⅛	6 15 10	February and August	12⅝	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	17½	17⅛
12,931	5	5⅛% 1889	Direct Spanish (£4 paid)	3⅛	4	3⅛	4	5 10 0	March & September	3⅝	3⅜
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10⅛	10⅜	10⅛	10⅜	6 15 0	Jan., Apr., July, Oct.	10⅛	10⅛
400,000	10	5/6	Eastern	13⅝	14⅛	13⅝	14⅛	4 12 0	" " " "	14⅛	13⅞
70,000	10	6%	Do. 6 per Cent. Preference	15	15⅛	15	15⅛	3 17 5	" " " "	15⅛	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	109	3 13 5	May and November	108⅛	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14	14½	14	14½	4 18 3	Jan., Apr., July, Oct.	14½	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	100⅛	..
91,800	100	5%	Do. 5 p. c. (Aust'n. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	101⅛	..
2145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	100	103	100	103	4 17 1	.. ..	..	..
180,227	10	4/3	Globe Telegraph and Trust	8⅞	9⅛	8⅞	9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅞	15⅛	14⅞	15⅛	3 19 4	" " " "	15⅛	14⅞
150,000	10	5/0	Great Northern	15⅝	16⅛	15⅝	16	4 13 9	Jan., April, and July	15⅝	15⅜
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100	103	100	103	4 17 1	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	37	39	37	39	6 8 2	April and October	..	..
33,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞	8⅛	7⅞	8⅛	6 1 3	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	112	116	113	117	5 2 7	" "	..	..
15,609	£10	6/6	West African	9	10	9	10	5 0 0	.. ..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	101⅛	100⅛
30,000	10	3/0	West Coast of America	5	6	5	6	..	January and July	..	..
150,000	100	8%	Do. Debentures 8%	106	110	106	110	7 5 6	June and December	..	..
88,321	10	Nil.	West India and Panama	2⅝	3	2⅞	3	..	.. ..	2⅞	..
34,563	10	6/0	Do. 1st Preference 6%	11½	11⅝	11½	11⅝	5 2 2	April and October	11⅝	..
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	12⅝	13⅛	13	14	4 5 9	.. ..	..	..
64,572	15	6/0	Western and Brazilian	10	10⅝	10⅝	11⅛	5 6 8	May and November	11	10⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6⅞	7	..	..	6⅞	6⅛
26,986	7½	4/6	Do. 5 per Cent. Deferred	3⅞	4⅛	4	4⅛	..	..	4⅛	4⅛
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103	106	103	106	5 13 2	.. ..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101	104	101	104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5⅜	Consolidated Telephone Const. and Maintenance	⅞	1	⅞	1	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	⅜	⅝	⅜	⅝	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅜	5	4⅜	5⅛	5 17 1	June and December	5⅛	4⅞
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12⅛	12⅝	12⅛	12⅝	4 14 1	June and December	..	..
15,000	10	4/6	Do. 6 per Cent. Cumulative 2nd Pref.	10	10⅛	10	10⅛	4 11 9	" "	10⅛	10⅛
209,750	1	⅛%	South of England, Ordinary	⅛	⅜	⅛	⅜	..	.. ..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd)	2⅜	3	2⅜	3	6 19 11	.. ..	..	..
55,000	5	1/0	United River Plate	4	4⅛	3⅞	4⅛	..	January and July	3⅞	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	.. ..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	1⅞	2	1⅞	2	..	.. ..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4	4⅛	4	4⅛	..	.. ..	4⅛	4⅛
42,853	5	..	Westminster Electric Supply	1⅛	1⅜	1⅛	1⅜	..	.. ..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1⅞	2	1⅞	2	..	.. ..	1⅞	..
63,416	2	1/2	Do. Preference	1⅞	2	1⅞	2	..	.. ..	1⅞	1⅞
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5½	5⅝	5½	5⅝	6 1 9	.. ..	..	..
353,478	5	..	Edison and Swan United	..		..		..	.. ..	..	..
400,000	10	..	Electric Construction	7⅛	8⅛	7⅛	8⅛	..	.. ..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	4	4⅛	5⅛	6	..	.. ..	..	..
20,000	5	..	Fowler-Waring Cables	2	2⅛	2	2⅛	..	.. ..	5⅛	4⅞
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18⅛	19⅛	18⅛	19⅛	5 2 7	February & August	..	..
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	.. ..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5	5⅛	5	5⅛	3 16 5	.. ..	5⅜	5⅛
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43½	42⅝
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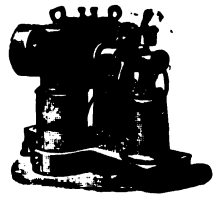

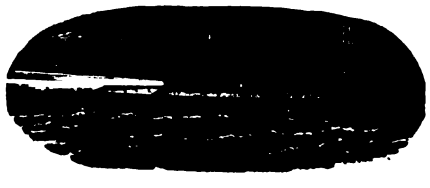

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NOTES.

On September 3rd, the sixtieth meeting of the British Association will be opened at Leeds by the President for the year, Sir Frederick Abel. Leeds offers several advantages on account of the great variety of industries which are carried on in its neighbourhood, affording opportunities for visits to a number of very interesting factories. A matter of greater importance to most members is the exceptional facilities which the district offers for excursions and picnics, both on account of the beautiful scenery and places of interest, including at least one abbey for each section, and a railway service which is unequalled in any other part of the country, and which will surprise those who are accustomed to the railways of suburban London.

Up to the present time the following Electrical Papers have been offered, and these are chiefly in Section A. They include "Regional Magnetic Disturbances on the Weald," by Profs. Rücker and Thorpe. "Suggestions towards a Final Determination of the Ohm," by Prof. J. V. Jones. "On the Electrostatic Forces between Conductors carrying Currents," by Prof. Oliver Lodge. "The Molecular Theory of Induced Magnetism" (with exhibition of a model), by Prof. J. A. Ewing. "The Effect of Oxidation on the Magnetic Properties of Manganese Steel," by Mr. L. T. O'Shea; and four short papers by Mr. Swinburne, on "The Compensation of Alternating Current Instruments," "The Resistance of the Human Body under Direct and Alternating Pressures," "Notes on High Vacua;" and, in conjunction with Mr. W. F. Bourne, "Testing Iron." In Section G, a paper on the "Lineff Tramway" will be read by Mr. Kapp; on the "Column Printing Telegraph," by Mr. Higgins (described in *The Electrician*, December 23rd, 1887, vol. xx., page 155); "Alternate *v.* Continuous-Currents, in Relation to the Human Body," by Mr. H. N. Lawrence and Dr. Harries; "Secondary Batteries," by Mr. Barbour Starkey; "The Victoria Torpedo," by Mr. G. Read; a Paper probably on the Distribution of Electricity, by Major-Gen. Webber; and one or more Papers by Mr. Preece. Although this list is brief compared with that of last year, communications may of course be expected from Sir W. Thomson and others, together with reports of various Committees, including one on Electrical Units.

Few districts have been so coveted by the purveyors of electric light as that of the City of London. Mr. Crompton quietly selected the best bit of Kensington before any one else was ready; and the St. James and Pall Mall Company appropriated, without much opposition, the important bit of Club-land which had been pointed out by Prof. Forbes. The London Electric Supply Corporation cast their net of wires far and wide; but the City has listened to no one but those indefatigable members of the Commissioners of Sewers who have made reports, received reports, and referred reports from one sub-committee to another since the spring of 1883. Mr. Preece has probably examined and reported upon as many tenders, offers, and schemes for lighting the City during the last seven years as would suffice for the illumination of every town in England, if only they were practicable. At Major Marindin's inquiry, the representatives of the City appeared to be struggling against the introduction of electric light into their sacred precincts, as though it were some pestilence. No concession or compromise would please them, nor could anyone else comprehend the peculiar privileges and ancient customs which they feared would be imperilled.

It would have been hard, indeed, if the Brush Corporation had not succeeded in securing a slice of the City after the repeated efforts which they have made; but it was scarcely to be expected that a similar share would have been given to a firm who have not yet done any supply in London. Excellent as the results of Messrs. Laing, Wharton, and Downs' work has been at Taunton, Exeter, Weybridge, and other places, we have yet to see how they will carry out street work under the special conditions imposed by the City. There is little doubt, however, but that it will be well done. The third and westerly district will not be allotted this year; but we understand that a keen competition is going on between various firms, among whom the two we have mentioned are included. The first step that has to be taken is to find the capital for carrying out the work. There will not, probably, be any difficulty about this, as the success of electric supply has been so firmly established during the last two years that the satisfactory lighting of the City is assured.

No doubt those who have studied the matter can judge of the relative values of the three districts into which the City has been divided. The cream of the lighting has not been taken by such private plants as those which supply the theatres and hotels and other important establishments of the West End. These can well compete in the matter of price with supply companies, since they have no street mains to lay

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and maintain, and need no staff worth mentioning. The bulk of the lighting will cease at the time when the load at the West End is heaviest; but the demands when a sudden fog comes on will tax the stations severely. There should be a good field for motors for hoisting and for lifts, especially in the Eastern District; while motors for printing should form an important item in the Western Division. When the mains are laid down in Salisbury-court we shall be prepared to accept a fifteen horse-power motor, with all the latest improvements, and will make no charge for giving it a few years' steady testing on our presses.

MANY of the improvements in the steam engine of to-day are due to the demands of the electrical industry, while the high-speed engine, though introduced some years ago on grounds of economy of steam and reduced first cost, has established itself, in spite of the prejudices of the old school of engineers, mainly on account of the needs of electric lighting. Prof. ROBERT THURSTON, in the article of which we give an abstract in another column, says that the demands for uniformity of speed exacted by the requirements of cotton-spinning machinery have been met by the use of governors which control the speed to within 1 per cent. of the mean, and within a total range of 2 per cent.; but that in electric lighting the range considered allowable is often half this amount, and he further adds that some makers guarantee that the fluctuation shall be imperceptible from full load to no load. In former years those who required uniform speed had great difficulties in compelling engine-builders to supply good governors. The old slow-speed governor of WATT, acting on a throttle valve, was good enough to prevent a runaway, and in many cases the driving shafts were burdened with huge fly-wheels in the mistaken idea that these will cure the evil which the introduction of the high-speed governor did much to alleviate.

COTTON spinners in this country, remembering the struggle which they had for regular speed, are generally under the impression that their engines are singularly perfect in this respect. We remember a case where a water-wheel, a beam engine, and a horizontal engine all strove together to do their best to drive a mill. A dynamo was put down for some experimental lighting. Complaints arose about irregular light, and before long, about lamp breakages; the latter indeed caused the lighting to be abandoned, in view of the probable cost of renewals. Nothing would induce the proprietors to believe that their speed varied; and the suggestion of an electrical regulator was tantamount to an insult to the venerable driving plant. Makers of accurate governors have successfully used the Moscrop speed indicator to give legible evidence of irregular speed and the efficacy of their appliances; and their results are often very remarkable. The range of one or two per cent., however, which Prof. THURSTON speaks of, has, we believe, been unknown among our textile manufactures until the last few years, and very rarely is it to be found at present. For dynamos coupled direct to separate engines, an exact control is not of great importance, as the inaccuracy of the engine can generally be satisfactorily accommodated in the compounding of the dynamo. The subject is being discussed by Mr. SWINBURNE in a series of articles in *Industries;* we give an abstract of the first one in this issue, as the subject is of very great importance.

OF making of new dynamos there appears to be no end, especially on the other side of the Atlantic, although on this side we seem to have settled down to two or three distinct types. This is, at least, the case with direct-current machines, and will probably soon be true also of alternators, in which at present some little uncertainty still exists, doubtless to be rapidly removed. The new welding machine of Prof. THOMSON, which we illustrate this week, is an attempt to generate the current at the welder, instead of conveying it as a high-tension current to the welder, and there transforming it into a low-tension current by means of a stationary transformer. It will be remembered that Prof. THOMSON started his welding work by using a direct-current dynamo on which the welder was placed, thus avoiding the necessity for conveying the large currents by large and costly conductors. There is a partial return to this plan in the present case, the chief difference being that the machine is made to give an alternating current, and does this by means of a fixed armature so as to avoid the collection of the current by rubbing contacts, a small coil on the fixed armature being used in conjunction with a commutator for the purpose of exciting the field by a "re-dressed" alternating current. There would seem to be no particular advantage in this plan. The use of a dynamo at each spot where welds are made is attended by practical disadvantages. Space must be found for the dynamo; and, although this may not be a serious matter, the further disadvantage of having to provide means for driving the machine must be inconvenient in many cases. The plan of having the generating plant at a distance and placed where it can readily be looked after, seems alone sufficient reason for adhering to the alternate-current arrangement with a transformer. As to the dynamo, the resemblance to the old AYRTON and PERRY motor and to the "Topf maschine" of SIEMENS shown in the Paris Exhibition of 1881, will at once strike our readers, who will doubtless agree with us that Prof. THOMSON, in working up this old idea for his new and interesting purposes, has not made a very good use of his material.

THE treatment of magnetic induction as something produced in the iron, alluded to by Dr. FLEMING in another column, and the use of the term gilb to signify the unit of induction, would remove a difficulty which many students have felt in connection with the notion of lines of force. That so many ampere turns under certain conditions produce so many lines of force is simple enough; but what would happen if the number of lines were reduced to less than one? What kind of thing is half a line of force? It is true that the idea of tubes of induction was invented to obviate this difficulty; but we prefer the gilb.

A FRESH determination of the ohm has recently been made by M. WUILLEUMIER, who has arrived at results in very close

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agreement with the best values yet obtained. The measurement of resistance, the dimensions of which in electro-magnetic measure are those of a velocity, generally resolves itself into the determination of a speed and a length, other measurements being of minor importance; and the best methods are those for which the formula required is of a very simple character, involving but few quantities, and in which the length and time elements are directly apparent. These advantages are all secured in the modification of LIPPMANN'S electro-dynamic method, adopted by M. WUILLEUMIER. A current of about 12 amperes was passed through a long solenoid and a standard coil having a resistance of about $\frac{1}{3}$ ohm. A small coil was turned at a uniform speed within the solenoid; and, at the point of its revolution at which the induced electromotive force is greatest, contact is made with the two extremities of the standard coil, a capillary electrometer being used to test the balance between the induced electromotive force and the difference of potentials set up by the current in the standard coil. By assuming the solenoid endless, the formula becomes very simple indeed, and the correction caused by its finite length is obtained entirely by experiment, and in an easy way. After several attempts had been made to secure a better one, the method finally adopted for measuring and governing the speed was very similar to that used by Lord RAYLEIGH in his experiments; and it is curious that the friction of a cord against the hand forms the best mode of regulating the constancy of the speed in such experiments. The apparatus employed was remarkable for its large dimensions, and we believe it is the first time that a current so large as 12 amperes has been used for the absolute measurement of resistance. The employment of the capillary electrometer in this connection is also a novelty. M. WUILLEUMIER finds 106·27cm. as the length of the mercury column, of one square centimetre section, whose resistance is one ohm.

ON the general question of the resuscitation of dormant patents, in view especially of the recent attempt, not yet abandoned we believe, to revive and claim royalties on the very ancient patent of Mr. LANE-FOX, we cannot help thinking that the rule in force in more than one foreign country, that a patent must be worked by the inventor within a year or two from the sealing of the patent, is not without its advantages; and we commend this point to the attention of our legislators. It cannot be to the general interest of the community that trade and industrial energy should be threatened with surprises of this sort. No one grudges an inventor an ample remuneration for his work; but if he deliberately allows others to do it without protest for many years, it is doubtful whether he is equitably entitled to any recognition other than the honour of priority of invention; and he must not be surprised if resistance is offered, such as that of the Defence Association whose circulars will be found in another column.

BY the courtesy of the officials of the Electric Lighting Department of the Board of Trade, we are able to give in this issue a complete list of the Provisional Orders which have received royal assent during the recent Session of Parliament. The information may be considered as official and thoroughly accurate, and is now published for the first time.

THE regulations issued by the Boston Manufacturers' Mutual Fire Insurance Company do not contain any solution to the difficulties which are felt so keenly in this country. The word "approved" often occurs in the specifications of architects and of engineers, but "approved substantial supports," "an approved, moisture-proof, non-inflammable, insulating tubing," are expressions that should not be used in the rules of an insurance office. Most people will agree with Major FLOOD-PAGE that there should be but one set of rules, and we are not disposed to quarrel with his selection of those of the Phœnix office; but he does not touch on the sore point. It is not the rules, but their interpretation that causes the trouble. If this or that material or method may sometimes be used, and may sometimes be condemned, why not say at once: Rule 1,—Wires, insulated in an approved fashion, are to be erected in an approved manner; Rule 2,—Switches and all other accessories are to be of an approved pattern?

Electric Lighting at Berlin.—The electric light is to be adopted at all the railway stations in Berlin and its suburbs.

Electric Railway at Prague.—The Town Council has granted a concession for an electric railway from the Belvedere to the Baumgarten.

Woolwich.—The Local Board have given their consent to the Woolwich District Electric Light Company lighting the town with the electric light.

A New Professorship.—At the commencement of the next Session of the Conservatoire des Arts et Métiers a chair of Industrial Electricity will be created.

New Board of Trade Rules.—A set of rules relating to the method and procedure for applications for licences and Provisional Orders was issued on Tuesday last.

New Portuguese Cable.—The Government has been authorised to lay down and work at the expense of the State a cable to connect Lisbon with St. Michael, Terceira, and Fayal.

Telephone Communication between Ulm and Friedrickschafen.—A double conductor, 104 kilometres long, of bronze wire, three mm. in diameter, is now at work between these towns.

La Societe Parisienne de Force et d'Eclairage.—This Company has been definitely constituted. M. Griolet, Administrateur of the Chemins de Fer du Nord, has been nominated as President of the Executive Council.

Traction by Accumulators at Hagen.—We are informed that the Company into which Messrs. Müller and Einbeck's business has been turned has equipped a car with Tudor accumulators for running on the Hagen tram lines.

Train Lighting in Russia.—The Russian Government, anxious to see the wholesale introduction of electric lighting for trains, has decided that all the carriages of the State railways are to be lit by electric light after this month.

The Electric Meter Competition at Paris.—We would remind our readers that instruments intended for this competition, of which we published the rules some little time back, should be sent in before the end of the present month.

Sheffield.—It was decided at a meeting of the Town Council last week to decline to approve of the applications made by the Electric Installation and Maintenance Company and the National Electric Supply Company for Provisional Orders, inasmuch as the Council intend themselves to apply for an order.

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Telegrams to Heligoland.—The charge per word for telegrams to Heligoland has been reduced from 4½d. per word to 2d. Two new cables, it is stated, will be laid down between Heligoland and the mainland. One will be laid to Wilhelmshaven, and the other will pass over the Island of Amrom.

Chester.—At a quarterly meeting of the Town Council it was recommended that the Bill confirming the Provisional Order authorising the supply of electricity within the city having received the Royal assent, it be referred to the committee to report as to the course most advisable to take for putting the powers of the order into execution.

Telpherage.—A concession for a telpher line for postal service between Buenos Ayres and Monte Video has just been granted to a Company. In the distance of 300 kilometres which separates the two cities the line will cross the estuary of the Plata, the width of which at this point is 30 kilometres. The passage of the postal boxes will be made in two hours.

University of Glasgow.—The next session commences on November 4th. Courses in Civil Engineering and Mechanics are conducted by Prof. Archibald Barr, D.Sc., M.I.C.E., and Naval Architecture and Marine Engineering by Prof. Philip Jenkins, M.I.N.A. Prospectuses and other information may be obtained from the Assistant Clerk at the Matriculation Office.

Electric Traction at Gera.—According to the *Elektrotechnisches Echo*, the Town Council of Gera have decided to grant the application of Messrs. Hostmann and Co., of Hanover, for permission to work three tram lines by electricity. The system adopted will be that of Sprague, whose patents for Germany have been acquired by the Allgemeine Elektricitäts Gesellschaft.

Telephone Communication in Italy.—From the *Elektrotechnische Zeitschrift* we learn that telephonic communication is to be established between Rome and the following towns: Naples, Florence, Genoa, Turin, Milan, Venice, and Spezzia; also between Turin and Milan, Milan and Venice, Genoa and Turin, Genoa and Florence, Naples and Palermo, and Messina and Palermo.

Worcester.—At the meeting of the Watch and Lighting Committee last week, Alderman Hill in the chair, the Town Clerk reported that electric lighting powers had been conferred on the Corporation under a Provisional Order. He suggested that some electric lighting companies should be communicated with in order to ascertain upon what terms they would carry out the work for the Corporation. The matter was referred back to the Lighting Sub-Committee.

Monopoly of Gutta Percha from Sierra Leone.—The President of Liberia has issued a proclamation, securing to the Liberian Concession Company (providing they comply with certain conditions previously agreed upon) the sole right of exporting all caoutchouc or rubber and gutta-percha gathered or collected within the Republic; and also announces that the violation of their said right by any individual shall be deemed a misdemeanour, punishable by a fine of not less than £1,040, nor more than £2,080.

Electricity at the North-West German Industrial Exhibition at Bremen.—The Electrical Section of this Exhibition is said to be of a very complete nature. Most of the well-known German firms have sent exhibits. The electric lighting is in the hands of Messrs. Siemens and Halske, Schuckert and Co., and the Bamberg Electric Company. The working of a street railway from the city to the Exhibition shows, it is said, for the first time in Germany the application of the Thomson-Houston system to traction work.

Proposed Extension of the Bradford Station.—At a special meeting of the Gas and Electricity Committee of the Bradford Corporation, held on the 8th inst., tenders were considered for the supply of engines, &c., required for the extension of the electricity works. The matter was referred to the Electricity Sub-Committee. The latter considered a tender of Messrs. Siemens Brothers for the supply of engines, &c.; but the prices in it were regarded as too high, and the town clerk was instructed to write with a view of having them reduced.

Telegraphic Extension to Tonkin.—A junction has recently been made between the telegraphic system of China and that of Tonkin, at a spot about 220 yards from the well-known port, Nam-Quan. This extension will enable the consulate of Longtchéou to be placed in direct telegraphic communication with France. According to the *L'Ingénieur-Conseil* there will be no difficulty in communicating with the Chinese offices, since by means of a special and well-understood code it will be possible to translate the telegraphic characters and transmit the messages to their destination.

The National Electric Light Association.—Last week we gave a list of the Papers to be read at the Convention at Cape May, New Jersey. The following particulars given by *Practical Electricity* are at least as interesting as the titles of the communications, and might be studied by one of the numerous committees of the British Association:—"The way the time will be spent there: Breakfast from 6 to 10:30. Morning session of Convention from 10 to 12. Bathing from 12 to 1. Dinner from 2 to 4. Afternoon session of Convention from 4 to 7. Supper from 7 to 9. Orchestral concert or hop from 9 to 11."

Telegraphists.—In answer to Mr. P. O'Brien on Friday night last, Sir H. Maxwell said, the scale introduced on July 11th last fixed the wages of second-class telegraphists at 12s. a week for the first year, at 14s. a week for the second year, and at 18s. a week for the third year, thereafter rising by 2s. annually to 40s. a week. This scale is on the whole better, far better, than the one it superseded. In connection with the old scale, however, there was an arrangement under which a learner, if fully qualified, could receive 16s. on appointment, and it is being considered whether a similar advantage should not be given to those learners whose employment began before the new scale was introduced.

Lighting of the Natural History Museum.—Sir G. Campbell, on the vote for the British Museum, asked in the House of Commons whether arrangements could not be made for the lighting of the Natural History Museum so that it could be used in the evening. Mr. Jackson said that, as the introduction of the electric light was a matter of experiment, it had been thought advisable to begin with the British Museum, because it was nearer to the masses of the people, and was more easily reached by them than was the Natural History Museum. The same pressure had not as yet been put upon the trustees to light the Natural History Museum, but experiments would be made with a view to the illumination of the building should it ultimately be determined upon.

Gas and Electricity.—At the half-yearly meeting of the Liverpool United Gas Light Company, on the 19th inst., the Chairman stated that he had never been one of those who poohpoohed the question of electricity. He always recognised it as a most important factor, and could only say now, as he had done before, that there was nothing so far to cause the slightest uneasiness to the proprietors of gas stock. It was quite true that the consumption of electricity in Liverpool was increasing, and therefore to a certain extent the consumption of gas by those who had used it before was decreasing; but the decrease was by no means to be compared with the increase that was going on. For, in spite of what electricity had done, the consumption of gas in Liverpool during the past year had increased by 2 per cent. Of course, they must look to an extension of electricity, but they might just as safely conclude that other uses for gas would be found, that a steady consumption of gas would continue, and that the property of the company would be just as safe now as it had been in the past.

The Telephone Monopoly of the German Post Office.—Until lately the German Post Office claimed the sole right of erecting or licensing private telephone installations, thus prohibiting the development of a convenient means of communication, and excluding the legitimate industry from a branch which ought to be its domain. Messrs. Mix and Genest, of Berlin, determined to test the legality of this proceeding in a court of law, and brought an action against the German Government claiming that the German Post Office had no right to restrain or prohibit the plaintiffs from erecting and maintaining private

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telephone installations, (a) between buildings belonging to the same landlord, but situated at a distance from each other, and separated by property of other landowners, or by public roads or otherwise; (b) between property belonging to different landlords, *i.e.*, from one part of a city to another. This claim was decided on July 10th last, thus putting an end to a state of things which has lasted too long to the disadvantage of those interested in this daily progressing industry.

Fire at the Edison-Swan Factory.—A fire broke out in the depositing rooms of the Edison and Swan Company's Factory at Ponder's End on Tuesday morning. This portion of the factory is divided from the remainder by a thick party wall of great height. The cause of the fire was, it is stated, an extra pressure, by which an electric spark ignited some benzoline used in the work. The fingers of the girl using the benzoline were hurt, but about 50 other girls to whose benches the fire quickly spread were got out of the place uninjured. The local fire brigade attended, but their efforts were confined to preventing the flames from going further. They thus saved the remainder of the premises, but the depositing building was destroyed. The factory has been carefully constructed in separate fireproof portions, on the same principle as the water-tight compartments of a ship, with the view of confining any outbreak of fire to the room in which it might originate. In the present case we are glad to learn, on making inquiries, that the damage has been entirely confined to the room in which it broke out. Owing to the large stocks in hand, the Company will experience no difficulty in executing orders, but they ask the forbearance for a few days of customers from whom they have orders for special lamps.

Electric Light at the Agricultural Exhibition at Vienna.—From the *Neue Freie Presse* we learn the following particulars of Siemens and Halske's installation at this Exhibition:—16 Siemens and Halske dynamos are driven by 11 steam engines supplied with steam from six boilers. The machines supply 400 arc lights and 2,000 incandescents. The arc light machines work at 300 volts and can each supply 72 arcs of 2,000 normal candle-power, and taking 10 amperes. Altogether, these machines supply 400 arcs in the Rotunda and the Park. The incandescent lighting machines, five in number, can each feed 500 16 candle-power lamps at 110 volts. For the illumination of the fountains two separate dynamos are employed, supplying together 660 amperes at 80 volts. There are altogether 72 arc light circuits, six incandescent circuits, and two for the fountains. Their total length is about 60 kilometres, of which about 17 kilometres consist of lead-covered cables, placed underground. This installation is said to be the largest in existence in Austria. About 675 horse-power are converted into light. Up to the present the installation has been run without the slightest hitch of any kind.

Train Lighting in Australia.—The Railway Commissioners of Sydney have recently made a very successful experiment in connection with the lighting of railway cars with electricity. The system now introduced is exceedingly simple. Two accumulators, each containing 14 Crompton cells, and weighing about half a ton, are placed under the carriage, and at convenient distances between the bogies. These are charged from the dynamos at Redfern required for the electric lighting of the station, and they are calculated to feed the six 16 candle-power Thomson-Houston lamps for about 14 hours. The *Sydney Mail* says that it was decided to use the Crompton cells, because they take up much less space than any other, are of less weight, are more perfectly insulated, and are more easily recharged. The system is completely under control, and the power of the lights can be regulated at will; and, what is of importance, the cost, it is estimated, will not exceed that of gas. The Commissioners first of all intend to apply the change to the sleeping cars attached to the express, and then probably one of the suburban trains will be lighted throughout by electricity. In the summer time the change will be appreciated, for the heat of the cars at night will be materially lessened.

The Generation of Electricity by the Tide.—A French engineer, M. Decœur, proposes to supply electric power to Paris by utilising the flow of the ebb and flood on the coast. For this purpose he intends to construct, near Havre, two large basins joined to each other, into one of which the sea at flood-tide flows over a dam, while during ebb it flows out of the other into the sea again. At the inlet and outlet M. Decœur proposes to erect a number of powerful turbines for transmitting the energy of the water. The mechanical energy thus produced M. Decœur estimates, with a tide of 18ft., which is the average at Havre, at six horse-power per hectare of basin area. He intends parting off by means of a dam 16½ miles long an area of 7,000 hectares between Havre and Tancarville from the sea and the Seine respectively, and thus creating 42,000 horse-power, which power he transforms into electrical energy and transmits to Paris. M. Decœur's scheme is looked upon with favour, and although the estimated net profit of 8,500,000fr. is too high, the *Morning Post* says that there are indications that it will ultimately be carried out. In his Presidential Address to Section A at the British Association Meeting of 1881, Sir William Thomson pointed out the impracticability of such schemes; and on the subject of building dams said, "If so much could be done, it would in many cases take only a little more to keep the water out altogether, and make fertile land of the whole basin."

Improving the Dynamo.—Under this title appears the following editorial note in the *Electrical World* of New York; some of the suggestions are noteworthy, but in this country commutators are not unfrequently the pride both of the manufacturer and of the attendant:—"It is a very remarkable fact, that in less than a score of years the dynamo should have reached so high a state of development that so far as efficiency is concerned there is little left to be done. The best dynamos to-day actually return as electrical energy more than 90 per cent. of the power used in driving them. Much beyond this we cannot hope to go, for we have no material of infinite conductivity, no insulator against magnetism, and no perfect lubricator. Even now slight increase in efficiency is often gained at too high a cost in material and labour. But the dynamo is by no means perfect yet; and it behoves inventors not to sit down and wait for the much-rumoured and never-seen methods of obtaining electricity direct from heat, but to sharpen their wits and go to work. And first of all, let them turn their efforts against that root of all electrical evil, the commutator. It has no virtues to speak of, and is a most fruitful source of trouble. We already have alternating dynamos quite free from its malign influence, and it is high time we had a continuous current machine of a similar sort. The problem is difficult, it is true, but there is no reason to think it impossible, and we commend it to the attention of the inventors who now fritter away their talents devising cruel and unusual forms of field-magnets. The commutator must go."

Fire Insurance Rules.—Major Flood Page, writing to the *Times* of yesterday, says that, having been consulted as to the rules that should be adopted by the Corporation of a small town, he communicated with the chief fire insurance offices. He gives the following analysis of the replies. The 33 offices from whom he has heard may be divided thus:—(*a*) Ten offices use the Phœnix rules. (*b*) Six offices use the Institution rules. (*c*) Ten offices have each their own special rules. (*d*) Seven offices have no special rules, but deal with each case as it arises. (*e*) Seven of the above offices send out a list of questions which must be answered by those who wish to have electric light in their houses. On the ground that the foundation on which other rules have been built seems to be that of the Phœnix rules, he urges the other offices to adopt these, and gives the following quotation from the preface:—"Notwithstanding the number of years these rules have been in use, not a single instance of fire has occurred, neither has the slightest injury happened to any person from any electrical installation that has been placed up in compliance with them." The Major admits that he is aware that rules are not in themselves sufficient. Much will always depend on the care with which the inspector satisfies himself that the rules have been faithfully and properly carried out. Nevertheless, if all houses are wired on one principle, the work of the contractors will be simplified, it will assist the workman, and will facilitate the inspections which must always take place when the wiring is complete. And as he believes that the Phœnix rules have served as a model for every office which has special rules; as

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the Phœnix rules have stood the test of time and are known throughout the world; as they have been adopted in integrity by many of the offices; as they are understood and approved, except in one small detail, by the electrical trade, and are practically safe, he ventures to express the hope that offices generally will adopt them, unless and until they can find better and safer rules by which to work.

Cataphoric Medication.—This process of accelerating the passage of drugs through the skin by endosmosis in the direction from the positive to the negative pole, which is regularly practised, under medical sanction, at the Institute of Medical Electricity, has been experimented upon by Mr. Edison. He tried the application of the method to a patient suffering from an acute and typical form of gouty concretions, in December, 1889. This person volunteered to try the effect of the method. He was 73 years of age, and had lived an active healthy life until ten years previously. Concretions commencing continued to increase slowly until they assumed large proportions. The joints of the fingers were almost obliterated by concretion. The girth of the little finger of the left hand was, by careful measurement, 8·6 cms., that of the corresponding finger on the right hand even greater. The current generated from Mr. Edison's laboratory 120 volt dynamo, passed through about 5,000 ohms resistance, and entered a jar containing an aqueous solution of lithium chloride, density 1·08, in which the patient immersed his left hand up to the wrist. His right hand was similarly immersed in a solution of common salt. The current, after passing through his body, left the latter jar by a negative electrode. It was found that he could stand 20 milliamperes without inconvenience, and this strength of current was steadily applied for six days during four hours daily. At the end of that time the girth of the left-hand little finger was distinctly reduced to 8·2 cms.; the patient also experienced freedom from pain after the first day's treatment. He continued the treatment for two days more during the week following, and then the journey to and from the laboratory exhausted his strength. The finger girth, after fourteen days from the date of commencing treatment, was 8·0 cms., a total reduction of 0·6 cm. This was estimated to represent a reduction of 3 cm. of concretion on this particular finger, whose form facilitated accurate measurement. His general condition, beyond the weakness resulting from unaccustomed journeying, was temporarily ameliorated.

Efficiency of the Transformer.—Writing to the *Electrical Engineer* of New York, the source of the Papers of which we gave abstracts in our recent issues of July 18th and 25th, Mr. Swinburne says:—"In common, no doubt, with most engineers on this side of the water, I have read Messrs. Humphrey and Powell's Paper on the above subject, reported by you, and have been surprised at the results obtained. The loss by hysteresis comes out astonishingly small. There is one point, however, in the report of the Paper which is not clear, and that is the method of measuring the instantaneous values of the primary currents. The instantaneous electromotive force on two lamps in the primary circuit was taken and divided by the resistance of the lamps, the lamps having been previously tested throughout their range, so that a resistance corresponded to each electromotive force on them. There is nothing in the Paper to say whether the resistances taken in determining the instantaneous currents were those corresponding to the instantaneous electromotive forces, or to the effective electromotive forces. On looking up Prof. Ryan's classical Paper, I find the same uncertainty. I hardly like to suggest that Prof. Ryan and Mr. Merritt, or Messrs. Humphrey and Powell have made a slip here; but there does seem to be room for an error that would bring out the efficiency too high, especially at light loads when the lamps in the primary would be dull. The resulting determination of the power lost would be chiefly affected by the part of the current curve under the peak of the electromotive force curve, which, assuming the slip to have been made, would be too low. The top of the magnetising current would come too high, but this would not correct the error, as there is no electromotive force then. I do not see how this possible error could give rise to greater inaccuracy in one Paper than the other; even Prof. Ryan's tests of hysteresis losses are small. The hysteresis also varies with the load, which is curious. Prof. Ryan suggests that at full load the force on the coil shakes the iron. The force should not exist in a transformer, and depends on what Prof. Ryan calls the leakage and not on the total induction through both coils. Moreover, if the application of external energy, as in shaking iron, prevents loss from hysteresis appearing in the circuit, it is probable that the energy is lost as before, but is now supplied mechanically. But in the transformer the mechanical energy is itself supplied electrically, and so the loss by hysteresis would not be lessened by the shaking due to forces acting on the coils. I mention these points merely for elucidation; American colleges do practical work that puts ours to shame, so it would be unbecoming to attempt to criticise it from this side of the Atlantic."

Telegraphs and Electric Railways.—The Commercial Cable Company land their cable at Coney Island and continue it with an underground cable through Ocean Avenue and Brooklyn into the middle of New York, practically making the terminus of the cable in Wall-street, instead of landing at some secluded spot, and repeating the messages by a land line. The underground cable has four cores, separated from each other by about one thirty-second of an inch. The cable is connected to one of these, the diagonally opposite one is soldered to the sheath of the sea cable, and is used as an earth; the other cores are kept as reserves. Mr. Cuttriss writes to the *Electrical Engineer* of New York to say that everything has gone well until a few months ago, when they were troubled by occasional kicks on the receiving instrument; sometimes they would be so strong as to obliterate a signal. As these kicks are nothing unusual during the summer months, owing to thunderstorms and other atmospheric disturbances, they were for some weeks attributed to such causes. During this period it was also noticed, when testing the cable, that the mirror seemed to be very unsteady, and had erratic movements, which denoted by their abruptness that the cause of disturbance was near this end of the cable, and was such as might be produced by a small fault. To satisfy himself on this point, he had the cores cut at the cable house on Coney Island, and while he was testing the undergrounds, the electrician at Nova Scotia (the distant end) was also testing the sea cable. The results showed that both the undergrounds and the cable were in perfect condition, but it was observed that there was some disturbing cause in their neighbourhood; as, after perfectly discharging the cores, they would in a few seconds become quite heavily charged, always with the same potentials. So far, we had arrived at only negative results, as the kicks, &c., were still present on joining up the working instrument. About this time it came to his knowledge that there had recently been an electric railroad established, running from Prospect Park, Brooklyn, to Coney Island by way of the old Coney Island horse car road. It must be remembered that ocean cables are operated by a recording instrument that is so sensitive that a current of $\frac{1}{1000}$ of a milliampere will produce a distinct working signal; hence it is quite conceivable that, although the electric road does not in any part of its route approach our underground cables nearer than about half a mile, disturbances might be produced by the power used in starting and running the cars. The telephone was connected to the cable and a local earth; the sounds were so loud that they could be heard with the telephone a short distance from the car. The testing galvanometer, a Thomson astatic, of course could not pick up such rapid vibrations, but it shows deflections and kicks to such a degree that we have sometimes been obliged to give up testing and try at a more favourable time, such as 1 or 2 a.m. when the cars have stopped for the night. With telephones and ordinary telegraph instruments the use of a metallic circuit is a good protection, but in the present case it is proved that a metallic circuit through the disturbed district does not grant immunity from serious disturbances. One point is still to be determined in regard to this phenomenon, namely, to ascertain for a certainty whether the effects produced are to be attributed to conduction through the earth and water to our armouring, or if it is an inductive effect. The fact remains, that if electric roads should be greatly augmented in our vicinity, the disturbances will be seriously increased. The tests show our undergrounds to have a dielectric resistance of about 350 megohms per mile, so the idea of any leakage cannot be entertained.

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MAGNETISM IN IRON AND OTHER METALS.*—XXVIII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 402.*)

§ 105. **Results of Optical Measurements.**—The general results as to the action of strong fields which the optical method has yielded in the hands of Du Bois, are in complete agreement with those obtained by means of the isthmus method and narrated above. The magnetic force was not pushed to such high values, but the values were high enough to show that a close approach to a limiting maximum of I had been reached. With nickel, the force H was raised to nearly 13,000, with cobalt to 8,500, with steel to 4,500, and with soft iron to 2,500. The limiting values towards which I tended appeared to be 530 in nickel, 1,200 in cobalt, and 1,630 in steel (a hard English cast steel). In the case of iron, the experiments were rather less satisfactory, but pointed to a limit between 1,700 and 1,750. These values are given for observations made when the specimens were at a temperature of 100°C.; at ordinary temperatures the values would be rather greater, as was shown by comparative tests at 100° C. and at 0° C. It is clear that these numbers are in good general agreement with those that have been stated already, §§ 98–102. The following data are taken from Du Bois' Paper. Table XX. relates to a specimen of cast cobalt, tested at 100° C., containing 5·8 per cent. of nickel, and 0·8 per cent. of iron. An additional observation, made in the strongest field, showed that I at 0° C. was 1,232. Table XXI. relates to a specimen of hard-drawn best nickel wire, stated to contain 99 per cent. of nickel. Here, again, a low temperature observation in the strongest field made the value of I at 0° C. to be 579.

TABLE XX.—*Cobalt in Strong Fields at 100° C.*

H	B	I	μ
860	14,180	1,060	16·49
2,500	16,750	1,134	6·70
4,800	19,550	1,174	4·07
6,870	21,710	1,181	3·16
8,350	23,330	1,192	2·79

TABLE XXI.—*Nickel in Strong Fields at 100° C.*

H	B	I	μ
550	6,420	453	11·67
3,410	9,920	518	3·12
6,290	12,850	522	2·57
9,600	16,250	527	1·69
12,620	19,220	525	1·52

On making optical observations with a specimen of Hadfield's manganese steel—the non-magnetic steel spoken of in § 70—it was found that the amount of magneto-optic rotation of the polarised ray varied considerably when the ray was reflected from different parts of the same polished surface, from which Du Bois infers that this material is essentially heterogeneous, having relatively strongly magnetic layers interposed between non-magnetic or feebly magnetic portions of the mass. He supposes the structure to be laminar, but so fine-grained that to ordinary tests it appears homogeneous.

§ 106. **Magnetisation of Magnetite.**—Du Bois has applied his optical method to obtain absolute measurements of the magnetisation in strong fields of a crystal of magnetite (the magnetic oxide of iron, Fe_3O_4) which is the only substance that shares with iron, nickel, and cobalt the distinction of being strongly magnetisable. The results show† that there is a limiting maximum of I in magnetite with the value of about 350, and that saturation is practically complete with a force H of 1,000 or 1,500 units.

§ 107. **Experiments with Ellipsoids.**—Reference has been made to the preliminary experiments with ellipsoids by means of which Du Bois determined the values of Kerr's constant in specimens of the same metals as were afterwards tested in stronger fields by the optical process. The experiments with ellipsoids were important, not only as a means towards that end; they are interesting in themselves because they deal with a portion of the range in regard to which we have no other experimental data, namely, the portion which extends from H = 200 or so to H = 1,200 or 1,300. With respect to higher forces, we have the results of the isthmus and of the magneto-optic methods; with respect to lower forces, we have, of course, a mass of data; but between the limits named there is a gap which these experiments with ellipsoids are the first to bridge.

The magnetic force was applied by means of a coil, and the specimen was an ovoid or prolate ellipsoid of revolution 18cms. long, and 0·6cm. in diameter, which was kept at a uniform temperature of 0°C or 100°C. by applying ice or steam. Its magnetisation was measured by the ordinary magnetometric method, a compensating coil being used to balance the greater part of the action of the magnetising coil upon the magnetometer. The ratio of diameters being 1 : 30, a correction of 0·052 I had to be subtracted from the magnetic force due to the coil to find the true magnetic force (*see* § 26).

Du Bois gives the results in the form of curves connecting H with the magnetic moment per unit of mass, that is, per gramme.

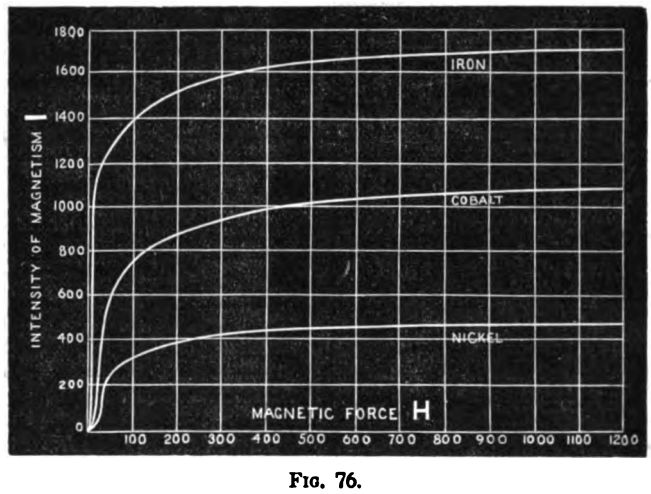

FIG. 76.

It will be more convenient for us to adhere to the usual practice of stating magnetisation by the quantity I, which is the moment per unit of volume, that is, per cubic centimetre. The results are accordingly reduced to this form in the curves of Fig. 76 and in table XXII., the numbers in which are calculated from measured values of the ordinates in Du Bois' curves.* The iron tested was soft Swedish wrought iron, carefully annealed.

TABLE XXII.—*Iron, Cobalt, and Nickel, in Moderately Strong Fields.*

Magnetic Force, H.	Intensity of Magnetism, I,		
	Iron at 0°C.	Cobalt at 100°C.	Nickel at 100°C.
100	1410	—	313
200	1520	856	375
300	1580	933	406
400	1627	988	428
500	1658	1018	441
600	1677	1032	450
700	1689	1048	456
800	1697	1056	459
1000	1705	1080	467
1200	1710	1090	471

The observations with cobalt and nickel were made at 100°C., but within the range of magnetic forces that is dealt with here the difference between 100°C. and atmospheric temperature has but little influence on the magnetisation.

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† *Phil. Mag.*, April, 1890, p. 301.

* *Phil. Mag.*, April, 1890, Plate 8, Fig. 1.

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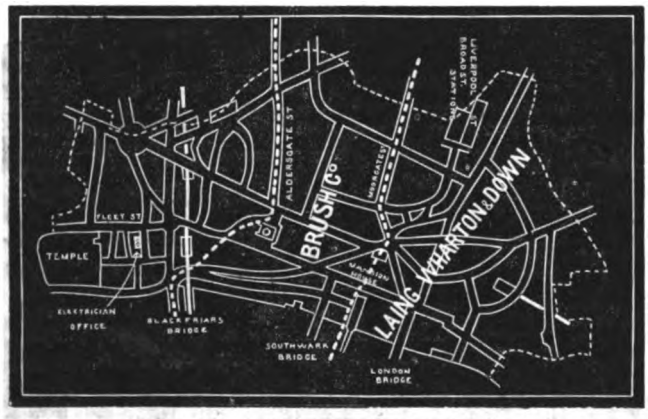
In Fig. 76 the same results are given, and the curves are completed to the origin (in an approximate fashion) by sketching in, from other data, the parts that relate to lower forces. The gradient of the cobalt curve at the upper end shows how cobalt needs a stronger field than the others to make its magnetisation approach closely to a state of saturation.

(To be continued.)

ELECTRIC LIGHTING OF THE CITY.

The Bill to confirm the Provisional Order for the lighting of the City came before the Unopposed Bill Committee of the House of Commons on Friday last, and was duly passed and confirmed. Under these Orders, the City is divided into three parts, according to the following map. The Laing, Wharton, and Down Construction Syndicate take the easterly portion, while the central portion is allotted to the Brush Electric Engineering Corporation. The Order differs from the Model Orders of the Board of Trade in containing a number of conditions which have been specially introduced by the City Authorities.



Map of the City of London. The heavy dotted lines indicate the boundaries of the three districts.

The streets throughout which the Brush Corporation have to lay mains within a period of 21 months are as follows :—

Barbican.
Beech-street.
Fore-street.
London Wall (west of Moorgate-street).
Gresham-street.
Upper Thames-street (west of Dowgate Hill).
Aldersgate-street.
St. Martin's-le-Grand.
St. Paul's Churchyard (south and east sides).
Wood-street.
King-street.
Cheapside.
Poultry.
Watling-street.
Cannon-street (west of Dowgate Hill).
Queen Victoria-street.
Queen-street.
Cripplegate-buildings.
Milk-street.
Aldermanbury.
Aldermanbury Postern.
Coleman-street.
Basinghall-street.

The streets through which the Laing Wharton and Down Construction Syndicate are to lay mains within 21 months are :—

Aldgate.
Aldgate High-street.
Arthur-street East.
Arthur-street West.
Bishopsgate-street Within.
Bishopsgate-street Without.
Cannon-street, east of Dowgate-hill.
Cornhill.
Eastcheap.
Fenchurch-street.
Finsbury-pavement.
Gracechurch-street.
Great Tower-street.
Houndsditch.
King William-street.
Leadenhall-street.
Liverpool-street.

The undertakers have to deposit a sum of one thousand pounds, to be repaid from time to time on certificate by an inspector of the Board of Trade. Besides the area shown on the map, the local authority, with the approval of the Board of Trade, may appoint to be included other streets or parts of streets within the City, the supply in these streets to be for public purposes only ; and the undertakers are to give such a supply of energy for the public lamps in the area of supply, and on such conditions, as may be for the time agreed upon between the undertakers and the local authority. Whenever the undertakers make default in supplying energy to the public lamps, they shall be liable to a penalty not exceeding forty shillings for each lamp, and for each day on which any such default occurs, provided that the penalties shall in no case exceed in the aggregate the sum of fifty pounds for any one day. No penalty shall be inflicted if the Court having cognizance of the case shall be of opinion that such default was caused by inevitable accident or *force majeure*, or was of so slight or unimportant a character as not to materially affect the value of the supply.

PATTEN'S IMPROVED MULTIPLEX TELEGRAPH.

The Patten multiplex telegraph, the following account of which is taken from a recent number of the *Electrical Engineer* of New York, bears a strong resemblance to the Delany system used by the Post Office. The details of the apparatus and the methods of synchronising are, however, different. The instruments are in use between New York and Philadelphia. This is a system of the synchronous multiplex type, depending for its operation upon the synchronous and uniform movement of two or more electric motors placed at distant points. In the present instance this is achieved by a novel application of the peculiar properties of electric motors, and the synchronism, far from being delicate, is powerful and reliable. The machine may evidently be of any size and power, and there is an evident tendency to run into synchronism instead of running out, which latter has been the case in former attempts at unison movements based upon the isochronous movement of a single machine. It is evident that an ordinary Siemens armature in a two-poled field must reverse its current at every half revolution. If by any means two such machines be caused to reverse their armature currents simultaneously, they would necessarily move in synchronism.

The apparatus used in the Patten system is simply an elaboration and practical application of this idea. Two electric motors at distant points are made to revolve in synchronism by causing the currents in the armature circuits to be simultaneously reversed through the agency of a controlling line current. The system will be understood from the illustration (Fig. 1), which is a diagram of all the operative circuits, including two terminal stations. The system is operated both as a single and a two-line system. In the two-line system a single synchronising line is used for controlling a movement of electric motors, and may be used to synchronise the motors for any number of lines. In the single-line system the synchronising current is used both for synchronising and telegraphing, without either function interfering with the operation of the other. For the sake of simplicity the two-line system is selected for description.

In Fig. 1, X and Y represent two terminal stations of a telegraph line. The synchronising line L L extends from the earth E^3 at X to E^4 at Y, reversing the polarised relays P^1 and P^2 at these stations. At any intermediate point in the line, whether at Y or X, or midway between, is placed a revolving pole changer, the function of which is to constantly reverse a current on this line derived from the synchronising battery 9. This pole changer is driven by an electric motor having independent field and armature circuits, by which means its speed may be regulated and controlled ; it is shown in the middle of the diagram. The lamps 11 are in the armature circuit in multiple arc, and by turning them on or off, the speed of the pole changer may be varied, the field remaining of uniform intensity excited by the battery 10. This pole changer sends rapidly reversed currents continuously to line, and maintains the polarised relays at X and Y in constant and rapid vibration. They necessarily beat in synchronism and are reversed by every half revolution of the controlling motor. These alternations set the pace of as many machines as it may be desired to place in circuit. Very little current is used for this purpose, the battery line on a 100-mile circuit having only about 30 volts potential. The current is necessarily very weak, and the vibration of the polarised relays is delicate but constant.

The armatures of these polarised relays could not carry sufficient current through their contact points to drive motors of any size or power, because of their lack of power to prevent sticking and welding at the contact points that would be occasioned by the making and breaking of such currents. To overcome this difficulty they are caused to drive a powerful vibrator in the same way that a relay actuates a sounder, the vibrator being placed upon a local circuit of low tension, V^1 V^2, and this is given sufficient strength and a suitable form to both rapidly reverse and convey the heavy currents of the motor armatures. These vibrators are shown at V^2 in the diagram, which is sufficiently clear to explain their operative parts. The polarised relay as it vibrates to and fro places alternately one

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side and the other of the vibrator in circuit, and its armature is rapidly and strongly pulled first against one contact point and then the other.

8 amperes at 16 volts, the pressure is sufficient to cause a heavy spark and flame at the breaking of such a current and to weld the armature to the vibrator points, and much time and labour was required

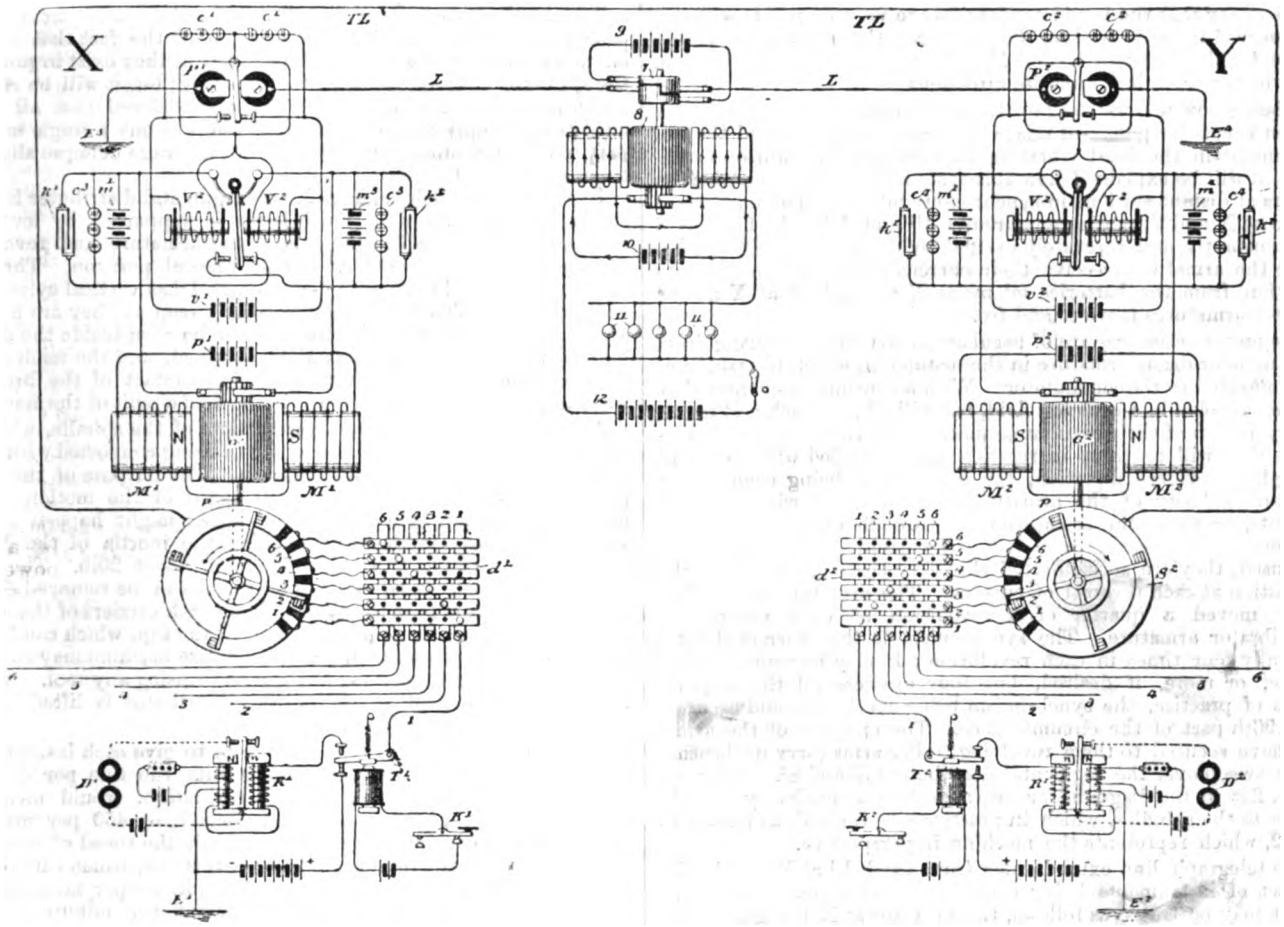

FIG. 1.—Diagram of Connections for Patten's Multiplex Telegraph.

The slight spark at the relay points is completely overcome by the liquid condensers C^2 placed as a shunt around these points.

to effectively overcome this difficulty. It may be said, however, that this current is now broken continuously at the rate of 800

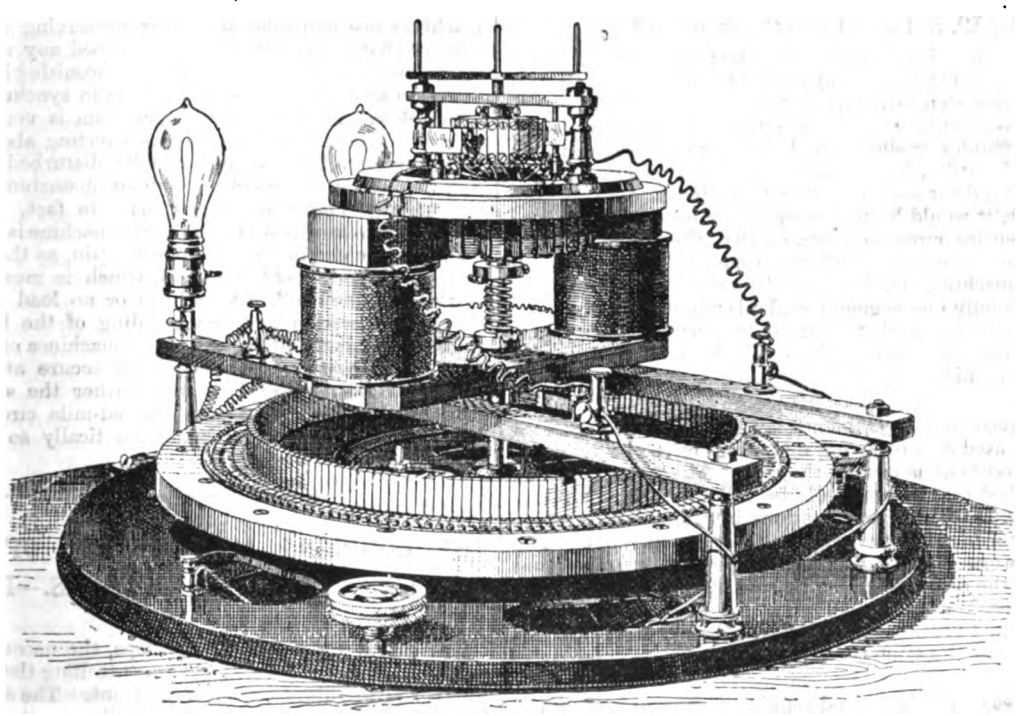

FIG. 2.—Patten's Multiplex Telegraph. General view.

With a small current this device is in every way sufficient to prevent any welding or sticking of the points. Not so, however, with the vibrator points. The armature current of the motors, being about

times a minute without producing a visible spark, and welding never occurs. This, which has been one of the greatest difficulties of the system, was effectually overcome by the system of devices

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shown. These consist in a special arrangement of liquid and plate condensers placed in parallel as a shunt around the armature points. Neither of these will suffice alone, and only a proper and particular combination of the two will effectually kill the spark. This combination has been found as the result of experiment, and it will suffice to say that the liquid condensers are very large. It will also be observed from the system of circuits that there is always a closed circuit for the batteries M^2 and M^4, which are alternately placed in the armature circuit in opposite directions.

It being now understood how the regulator at some intermediate station keeps the polarised relays in unison movement, and they in turn maintain the local vibrators in corresponding unison movement, it will be explained how this system of devices maintains the motors at distant stations in synchronous rotation. The motors are shown at X and Y by diagram circuits M^1 and M^2; the fields N S are constantly and separately excited by the batteries P^1 and P^2, while the armatures receive their current alternately in opposite direction from the batteries m^1 m^3 at X and m^2 m^4 at Y as the vibrator armatures move to and fro.

The motor armatures are of peculiar construction, differing from a Gramme or drum armature in the manner in which the windings are connected to the commutator. With a continuous current they will not revolve in a constant field, but will vibrate back and forth; but by reason of their peculiar connections to the commutator segments they will continue in rotation when supplied with a current of rapidly reversed direction, the connections being such that a constant polarity of the armature is maintained with reversed currents, provided the armature turns through a certain arc of the circumference at each reversal of the current. As the system is now used, they are so connected that they move one-fourth of the revolution at each reversal of current. The armature is therefore really moved a quarter of a revolution at each reversal of the vibrator armature. The synchronism is thus corrected automatically four times in each revolution; it may be made eight or twelve, or more, if desired, but four answers all the requirements of practice, the synchronism being continuous and accurate to a 196th part of the circumference. The spindles of the armature have secured to them revolving trailer arms carrying brushes which sweep over the segmental distributors S^1 and S^3. They are shown flat in the diagram, for clearness, but are evidently at right angles to the spindles, which in practice are vertical, as shown in Fig. 2, which represents the machine in perspective.

The telegraph line extends also from earth E^1 at X to E^2 at Y, one set of instruments being shown in detail at each end. The circuit may be traced as follows, the operator at X being supposed to be sending, and the operator at Y receiving:—From earth, E^1, hrough the line battery positive to line, transmitter contact T^1, switch d^1, segment No. 1 of the distributer, and through the trailing brush to the large segment of the distributer, to which the line is connected; thence over the telegraph line T L to the large segment S^2, out through the switch d^2, transmitter back contact, receiving relay R^2, and completing the circuit at E^2.

Among the many novel features in the systems is first the fact that the distributer is not necessarily cut up throughout its circumference, as in other systems of multiplex telegraphy, and there may be only as many segments as there are circuits to be used on the line. Thus a sextuplex is shown, and there are six segments in the distributer. In order, however, to acquire a sufficient number of contacts per second for each operator to maintain a practically continuous circuit, it would be necessary to connect No. 1 to four segments in the entire circumference, so that this instrument as well as all the others would receive four impulses of current at each revolution of the machine. The same result is readily accomplished, however, by using only one segment and placing four trailers on the spindle, so that one is always in contact with the segment, while the other three are connected to line by contact with the uncut portion of the distributer. This greatly reduces the cost of such devices.

The system of receiving instruments is also decidedly novel; a polarised relay is used as a receiving relay, but it is not operated with reversed currents as is usually the case. The polarised relay is indeed so modified that it can hardly be called a polarised relay, properly speaking, as by the modifications introduced it is made responsive to intermittent positive or negative currents. The system shown is worked with intermittent positive currents, and is also worked on the open circuit or English system, the receiving relays being rendered operative by putting battery to line from the opposite end, and breaking being effected by opposing the two equal line batteries at the same time from the opposite ends of the line.

One complete set of receiving and sending apparatus is shown at each end. Of course those connected to the main circuit 2, 3, 4, 5 and 6, are identical with those shown connected to the circuit 1. They consist of a key, a transmitter, and a receiving relay normally of the polarised form, but modified as shown in the drawing by the introduction of an extra energising circuit around one core of the relay, this slight modification rendering the relay operative under the action of intermittent currents of one polarity or sign only. The sounder, D^1, by which the message is read, is operated in the usual way when the receiving relay is actuated by an incoming line current. A sextuplex is shown in the diagram, although excellent results have been obtained on a hundred-mile circuit when connected as a "twelveplex." By reason of the fact that all the circuits are shown in the diagram complete as they exist in practice, the system has the appearance of complexity; but it will be readily seen that it is not really so when it is considered that all these circuits are simply magnets, and that there is but a single moving part in each machine, the motion of the vibrators being so slight as to be scarcely noticeable.

In the motor machine, Fig. 2, the segmental distributer is near the base of the machine, which latter is supported by levelling screws by means of which the axis of the armature and revolving fly-wheel can be brought to a true vertical position. The distributor is about 15in. inside diameter, and has vertical cylindrical walls, against which the trailing brushes sweep as they are carried around by the heavy fly-wheel which can be seen inside the distributor. An interior contact is thus obtained, and the tendency is always to increase and preserve uniform contact of the brushes. The lamps are used as resistances in the field circuit of the machine.

A noticeable feature is the construction of the spindle, which is in two parts, the upper and lower halves being connected with each other by a spiral steel spring, as shown. The purpose of this is to prevent any sudden jerk or change of speed of the motion of the fly-wheel, although such a change of speed might happen to the armature; it also facilitates overcoming the inertia of the heavy fly-wheel at starting, this wheel weighing about 20lb. The base is open at the bottom so that the fly-wheel can be removed downwards through a hole in the table. The brush carriers of the armature rest in a similar circular frame at the top, which can be removed by lifting it out of place. The entire machine may thus be dismantled without removing any screws or using any tool. When the fly-wheel has been taken out the distributor is lifted off its carriage and slid out sidewise.

The speed is so regulated in practice as to give each instrument, when its circuit is closed, 30 contacts with the line per second, which, admitting four contacts per revolution, would mean an average speed of $7\frac{1}{2}$ revolutions per second, or 450 per minute. But as the distributor motors move at half the speed of the controlling motor in the middle of the line, this one, which carries the pole changer, is driven at about 900 revolutions per minute, producing therefore 1,800 reversals of current per minute on the synchronising line, and a corresponding number of vibrations of the polarised relay armatures. But as four of these are required to produce a single revolution in the armatures in the distributer motors, their speed is brought to about 450, as stated.

One peculiarity will be observed, namely, that this is not a terminal system as is necessarily the case where isochronous machines are depended upon for preserving synchronism. It is evident that in the system here described any number of polarised relays might be connected in the synchronising line, and they would maintain as many distributing motors in synchronism. The movement of the machines and synchronism is very decided as would naturally be expected, the motors exerting about one-eighth of a horse-power. The machines may be disturbed and lifted off their base and allowed to drop, without disturbing the synchronous movement. The trailer arms may, in fact, be struck, and the synchronism disturbed, but unless the machine is completely stopped, it will soon come into synchronism again, as there is a tendency to automatically correct the motion, which is measured by the power of the machine itself, having little or no load to carry other than that due to friction and the grinding of the brushes against the walls of the distributer. By using machines of such power, however, these contacts are made very secure and reliable. Under ordinary conditions of line and weather the system will work at "twelveplex" on a good one-hundred-mile circuit with reliability and decision, the circuits being practically so many independent lines.

THE COUPLING AND CONTROL OF DYNAMOS IN CENTRAL STATIONS.—I.*

As central station work develops, the necessity for considering the best ways of governing or controlling the pressure of a large number of machines comes to the front. The subject has not yet been dealt with systematically. In direct current work, low pressure of 100 volts or so, is universally used, except in series arc lighting and distribution from batteries used as transformers, which are outside the scope of this article. Even parallel supply from

* Abstract of an article by Mr. James Swinburne in *Industries*, Aug. 15th.

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batteries and dynamos together will hardly be touched, as the pressure in the supply circuits then depends on the batteries, and is regulated by cutting cells in or out, and is not controlled by the dynamos, engines, or their regulating gear or governors. The three, four, or five wire arrangements are practically multiples of a single parallel system, and do not need special attention.

Direct-current station dynamos are always shunt-wound or separately excited. By separately excited it is not here meant that they have special exciters, but that the supply is taken from the mains. In this sense a dynamo running in parallel with a number of other machines may be regarded indifferently as shunt-wound or separately excited; and, as a matter of fact, the field-magnet circuit is always made before the armature circuit to ensure that the machine starts in the right direction. A number of shunt machines may be coupled together and regulated in various ways. In some cases each engine drives several dynamos, in others only one machine. Then the dynamos may have adjustable resistances in their field circuits, so that one field is altered at a time; or the whole of the field-magnet circuits may be arranged to be controlled together. Sometimes they are so arranged that each dynamo can be regulated by itself, and the whole of them can also be weakened or strengthened together as the load on the station falls or increases.

Take first the case in which each engine has a speed governor. Governors for engines are in the market in endless variety, and though great trouble and ingenuity have been spent, it is questionable whether mechanical governors have been studied from quite the right point of view. In the first place an engineer, in designing a governor, is far too apt to consider it by itself without taking the engine into account at all. This gives rise to several troubles. Many governors have been designed so as to be sensitive, and perhaps to be nearly isochronous when disconnected, but are then rendered quite useless by hanging on a heavy expansion link, or by setting the governor to work a stiff throttle valve or other gear. This is the commonest mistake of all in governor design. There is another more complicated question, which is of vital importance, and, so far as I know, has been little studied, and that is the question of "hunting."

Suppose an engine has a governor which, so far from being burdened with expansion links or gear, controls the trip gear of an engine on the Corliss principle. Suppose, instead of being perfectly isochronous, it is set to allow the engine to go 5 per cent. faster at no load. This governor may be arranged to respond to a variation of speed almost instantly, or it may have considerable inertia, or be provided with a dash-pot to make it respond slowly. Suppose, for example, that it responds fairly quickly. The engine has also a rate of response relatively to the governor. If the engine has a heavy fly wheel, and if it runs slowly, so that a cylinder full of steam represents a large instalment of energy, it will respond slowly to the governor, especially if the load is light. If, for instance, half the full load is taken off suddenly, the speed of the engine gradually increases, and the governor then commences to cut off the steam. The engine goes on increasing in speed as long as it gets more than half steam. We may suppose, for example, that the full-load speed of the engine is 100 revolutions per minute, and the no-load speed 105. At half load, the equilibrium speed should be 102·5. But as the governor does not respond instantly to the change of speed, by the time the governor has cut the steam down to half, the engine has quickened up to, say, 110 revolutions. The engine begins to slow down from that instant; but as the speed is above the governor's normal speed for half steam, the governor goes on reducing the steam. By the time the engine is down to 102·5 revolutions the governor has cut off far too much steam. It begins to increase the steam again, but the engine goes on slowing down till the governor gives it half steam. The engine then begins to quicken, but when it has got to 102·5 the governor has overshot its mark, and is giving too much steam. The engine then races again, and this cycle of things is repeated. It depends on the speeds of response of the governor and engine whether the hunting increases till the governor gives from no steam to full steam, in waves, or tapers off to a state of equilibrium—that is to say, of regular running. The speed of response of the engine varies with the load. An engine with a heavy fly-wheel and a light load will often hunt, and will run steadily when the load is put on. The hunting can be avoided by making the engine respond quicker, or the governor slower, or much quicker. The more nearly isochronous the governor is, the more tendency there is to hunting; and to avoid hunting it must then be made anisochronous, and it must respond very slowly. If it responds very slowly the engine may race on load being removed, or may slow down excessively on load being put on, the governor taking a long time to get to the proper position. This is, of course, very bad. Instead of making the governor respond slowly, the engine may be made to respond quickly. A heavy fly-wheel secures evenness from stroke to stroke of the piston, but it makes it difficult to govern as to average speed, for it makes the engine respond more slowly. Probably most of the difficulties in governing mill engines arise from the use of slow engines with big fly-wheels. On the other hand, a small high-speed engine is more easily governed. Even an engine like Willans', with a Willans governor, will hunt on light loads, unless the vibration period of the governor is made large. I have tried the same governor on a slower fly-wheel engine, and it was impossible to govern under one-third load. More recently I have made an electric relay governor to control an engine with an absurdly large inertia in proportion to its load, so that it responded to the governor very slowly. In this case the promptness of the governor could be reduced to any degree of slowness, and to get the whole into stable equilibrium the governor had to be made so slow that the period of the whole system was about fifty seconds. Even then, after a sudden change of load there was considerable hunting before the engine remained at its correct speed. In the case of electric lighting from stations, the tendency to hunt is often checked. In the first place, several engines and dynamos work in parallel, so that, unless they all hunt together, the proportion of load taken by each varies enormously with small changes of speed, and checks the tendency to hunt. Secondary batteries have also a similar effect. In the examples it was assumed that the load was independent of the variations in speed; strictly speaking, this is, of course, not the case. The variation of load with the speed, of course, also tends to check hunting—that is to say, it makes the engine respond to the governor quicker. The question of hunting is, therefore, not so important in direct current work, where many engines and machines are coupled together, as in alternating work, where one engine and one dynamo work one circuit. It is also important where one large engine drives many direct current dynamos not coupled to those driven by other engines. It is, therefore, worth while to go into the matter to some extent now, so as to avoid the necessity of returning to the subject of engine governors when I come to alternating current work.

So far, the governors have been supposed to be mechanical speed governors; electrical governors, of course, follow much the same laws. Dismissing all questions of hunting, the electrical government of a number of engines and dynamos, or, as they may be called for shortness, steam-dynamos, is very complicated. Take first the cases of a governor on each engine. If each is simply a pressure governor, it is controlled only by the station pressure, and the movement of the governor is not specially dependant on the doings of the particular dynamo it controls. The least inaccuracy in adjustment allows one dynamo to do more work than another. The governors only keep the pressure right as a whole, they do not know what share each dynamo gives. At first sight it would seem that an additional wire on each governor coil in series with the dynamo controlled by it would work, so that as soon as a dynamo gave more than its share of current its governor would shut off steam more than the others. This would, however, give a lower pressure throughout the station as the total load increases, for with the same pressure the ampere turns on each of the governors would increase with the load. The ampere-turns on the governor should remain constant, or if anything decrease, so that the station as a whole "compounds up" a little to compensate for losses in leads and feeders. To secure this some demagnetising current turns must be added to each governor, which are in series with, or proportional to, the current of the whole station. By making these slightly excessive compounding up of the whole station is secured. A new difficulty crops up, however. The demagnetising turns can only be permanently correctly proportioned if the number of steam-dynamos in use is constant, so that each always does the same share of whatever the output of the station may be. To avoid this difficulty means adding more complications to a system which is already almost too complicated to be of any practical value.

Instead of putting an electrical pressure governor on each engine, one may be put on the whole steam supply, or may be arranged to control all the engines by altering the ratios of expansion or otherwise. This arrangement has many advantages. An accurate governor that can be thoroughly depended upon is necessarily costly. It is much better, then, to put all the work into one thoroughly good piece of apparatus. Each engine can then have a speed governor set for twenty per cent. or so over normal speed, so as to prevent accident in case of a fuse going, or field circuit being opened from any cause. At light loads, if all the engines are on, of course the diagrams are bad, but an attendant shuts off steam from some and stops them, so that those running have fair loads. The stop valves are always full open or closed, the speed depending entirely on the main throttle valve. Instead of a main throttle valve, which is not always possible, owing to multiplicity of boilers, the expansion gear or cut-off or throttle on each engine may be controlled by the main governor. The action is radically different from that of an electric governor on each engine, for all the cut-offs or throttles are worked simultaneously and equally, so that there is no possible inequality of load among the dynamos.

(To be continued.)

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The Electrician.

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NOMENCLATURE AS AN ART.

In a recent Paper by a well-known professor at a colonial university the mechanical properties of quartz threads were discussed, and one of these is treated under the title of "Nachwirkung." There is nothing in the communication to inform the reader as to the signification of the term, other than that which may be inferred from the paragraphs which deal with it. As descriptive of some kind of rigidity or strength, it might be expected that the word would be found in text-books of mechanical science; but it is unknown there. The obvious translation "after-effect" might mean elastic fatigue, to which part of the Paper is devoted, or half-a-dozen other well-known physical characteristics. A study of the context will suggest that the German word may be translated yet more literally as "back-working." But why all this trouble and vagueness? The true use of words is to represent ideas; and whatever the professional politician may think, the man of science should carefully keep this use in view when he has to make an addition to our vocabulary. With the progress of science, new ideas spring into existence, and if they are worthy of discussion, they must be designated by some name; but the choice is a responsible matter. The sponsors to the phonograph, microphone, telephone, &c., have perhaps produced as graceful results as might be expected from the dead languages employed. We certainly prefer "telescope" and "telephone" to the "fernrohr" (far-tube) and "fernsprecher" (far-speaker) officially used in Germany. "Nachwirkung" is a ready made word, while "back-working" is too clumsy for a moment's consideration. If the term "creep" will not do—and we see no reason why it should not—the word "anherpēsis," creeping backwards, from ἀνά and ἕρπω, might be formed on the model of hysteresis, or the existing word "anachorēsis," a marching back, might be employed.

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Prof. TYNDALL, in writing on acoustics, uses the ugly word "clang" to denote the admixture of sounds existent in a complex musical "tone." He had the English words "tone" and "note" available, but accepted neither for the purpose. Moreover, he found no word by which to translate "klangfarbe," and discussed the merits of "clang" and "timbre," finally adopting the latter. But why introduce a foreign word, when "quality" is, for this purpose, a perfectly satisfactory expression? The French, it is true, are introducing English words almost daily into their technical literature. There seems to be a great poverty in the engineering and electrical portions of their vocabulary, and a reluctance to put together words to express the new ideas which are imported from other nations. The expressions "short-circuit," "shunt," "self-induction," "extra-courant," "switch," "torque," and others are examples. The Italian Government prefer to use the French language in diplomatic despatches, because it is conveniently capable of bearing so many different interpretations; and English for telegraphic purposes, because it is so economically concise in the absence of useless little particles, and because the meaning is perfectly definite. The flexibility of the English language for word-coining purposes is chiefly due to our habit of borrowing terms for use in one subject from the vocabulary of another. "Shunt" and "switch" are derived from railway practice. Their etymology is obscure; and, like many other colloquial technicalities, they are probably the wreck of other and less convenient names. In creating new terms we have a happy knack of using monosyllables, and we do not often build up compound words with a German disregard for euphony.

An article in the *Spectator* recently pointed out that it is better to wait until "the man in the street" finds a word for a new idea than to hastily manufacture such expressions as those which were proposed for expressing locomotion by electricity. The law of supply and demand must be obeyed in terminology as well as in dock strikes. It is useless to attempt to force the evolution of nomenclature. The neat name for the unit of conductivity, reciprocal of the ohm—the mho—has never "caught on," merely because the decimal system of notation is so much more popular than the binary system, and it is more easy to add resistances and find their reciprocals than to work with mhos. On the other hand, Sir WILLIAM SIEMENS suggested the watt at exactly the right time; it supplied the want which was just beginning to be felt, but which had not been expressed. The suggestion was received with applause, and the name was instantly absorbed into the vocabulary of electrical science. If "the man in the street" does not do his duty, there is a danger that some pseudologist may rashly give a nickname to the newest novelty. It is a mere coincidence that both "ammeter" and "secohm" are two of the most unhappy names we have. An ammeter is no meter, and an "am"—what is it? The instrument is a current gauge, and should have been so called. An attempt has been made to introduce this sensible name, but it is to be feared that "ammeter" has taken too firm a root. "Secohm" offends the ear, while it tells no tale. The "quadrant" is worse—but on purely scientific grounds with which we are not dealing at present, but which are discussed by Dr. FLEMING in another column.

There is, to our ears, a horrid vulgarity about "E.M.F.," which is the less excusable since the words for which it is the slang are themselves so inaccurate. Happily, there is but seldom any difficulty in substituting "pressure" or "volts" for that which is probably not electromotive, and which certainly is not force. Some purists think that "pressure" is a non-electrical word, borrowed, for want of a better, from mechanical science; but why so, more than "tension," which has been used and misused by the highest authorities? Tension used to be applied more frequently in cases where there was a great difference of potential, probably on account of a vague idea that there was a strain somewhere. If there be a strain, it is in the dielectric, not in the conductor. If Mr. FERRANTI has to deal with high tensions, they are those which exist *in* his insulating materials, not *at* his terminals. We like "pressure"; it is sufficiently accurate, and has the advantage of conveying a not erroneous meaning to the public. We cannot venture to guide the word-coiner in the art of supplying graceful additions to our terminology; but we have tried to point out some considerations which he would do well to observe; bearing in mind BACON'S remark—"And herein I cannot a little marvel at the philosopher ARISTOTLE, that did proceed in such a spirit of difference and contradiction towards all antiquity; undertaking . . . to frame new words of science at pleasure . . . wherein for glory and drawing followers and disciples he took the right course."

In conclusion we would note that there are in electrical engineering some curious coincidences between the names of inventors and mechanical appliances which have given rise to absurd mistakes. It was commonly supposed, some years ago, that the Brush machine was so called on account of some special kind of brushes. The Lever arc lamp, obviously because there were two peculiar levers in its mechanism. The Ball dynamo has no spherical armature, as might be supposed; the Short electric railway system is not specially adapted for lines of limited length. Bright shackles are never polished; and the Siemens' galvanometer has nothing to do with the mariners' compass, with which beginners sometimes confound it. The Parsons engine is not a clerical device; and the Upward battery has nothing in common with Excelsior carbons. Such popular errors may be excused, however, when we find a recognised text-book explaining the Daniell's cell as being so called because of its constancy!

THE LIGHTING OF LONDON THEATRES BY ELECTRICITY.

BY ED. C. DE SEGUNDO, A.M.I.C.E.

(Concluded from page 341.)

The Lyric Theatre (continued).—The following figures, showing the total cost of maintenance of the theatre, will, no doubt, be interesting to many, and—it must be remembered—they are taken from actual accounts paid from February 1, 1889, to January 31, 1890.

I give the exact figures supplied to me by Mr. Lyon:—

Maintenance of engines and dynamos, including wages of drivers, &c.	£507	10	7
Maintenance of accumulators	144	17	2
Gas consumed in engines, 6,854,000 cubic feet, at 2s. 6d.	858	0	0
Depreciation—			
Engines, at 10 per cent.	64	10	0
Belts, at 10 per cent.	5	0	0
Dynamos, at 10 per cent.	31	4	0
Accumulators, at 20 per cent.	460	0	0
Switch board, at 2½ per cent.	5	4	6
Wages: House and stage	277	4	5
Renewals, repairs, &c.	98	10	0
Cleaning lamps	5	19	9
Wages—Stage hands for performance	282	5	2
Carbons for arc lamps on stage and in front of house	15	5	6
Depreciation on plant in house and stage 5 per cent.	100	0	0
Superintendence	150	0	0
	£3,005	11	1

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The number of watts consumed in the lamps and leads outside the switch room was 93,188,000. Thus, had the light been supplied by a public Supply Company the cost would have been as follows:—

93,188 units at 7d.	£2,717	19	8
Stage hands would remain the same	282	5	2
House and stage	381	14	2
Switch room	100	0	0
Depreciation on £2,000 at five per cent.	100	0	0
Superintendence	150	0	0
	£3,731	19	0

And if the theatre were lighted by gas the estimated cost would be as follows:—

Assuming a 5ft. burner = a 16 candle-power lamp (this is a very liberal assumption in favour of gas) and estimating that 2,458 gas jets would be required to give the same effect as is now produced by the electric light, we have 2,458 5ft. burners burning five hours a day consume 61,450 cubic feet per day at 2s. 6d. = per year	£2,386	8	2
One gas man	130	0	0
Renewals, repairs, &c.	150	0	0
Two cleaners at 30s.	150	0	0
12 lime light men at 3s. each	590	0	0
Gas mains used for stage	142	6	0
Extra cleaning	25	0	0
Depreciation on plant in house and stage	100	0	0
Superintendence	150	0	0
	£3,823	14	2

Provided there has been no slip in Mr. Henry Lyon's estimates and no misunderstanding on my part, we find the exceedingly interesting result that the cost of lighting a large theatre entirely by gas or by electricity supplied by a public company is pretty much the same; whereas a considerable saving is effected by producing the necessary electrical energy on the premises. But, of course, the interest on the first cost, as well as a portion written off the saving to form a sinking fund, should be taken into account. In this particular case interest at 5 per cent. on the first cost would alone bring the cost of maintenance above either gas or electricity supplied by a public company. But it should also be remembered that the cost of the plant for this theatre was abnormally high. It is probable that had the installation been carried out with due regard to economy, the cost of maintenance, including interest, &c., would compare favourably with the cost of either gas or electricity supplied by a public company.

The Court Theatre.—This installation was designed and erected by Messrs. Sharp and Kent, of 34, Victoria-street, S.W. It is a remarkable instance of *multum in parvo*, for the complete steam generating plant, together with all necessary accessories and fittings, are contained in a space 20ft. long, 12ft. broad at one end, and 8ft. 6in. broad at the other, and about 8ft. high. The plant consisted of two return-tube single-ended marine boilers, with separate uptakes into a common chimney, working at from 120lb. to 130lb. per square inch; a double tandem compound Willans engine, coupled direct to an 18 unit Goolden dynamo, and a 12 unit Parsons' turbo-generator.

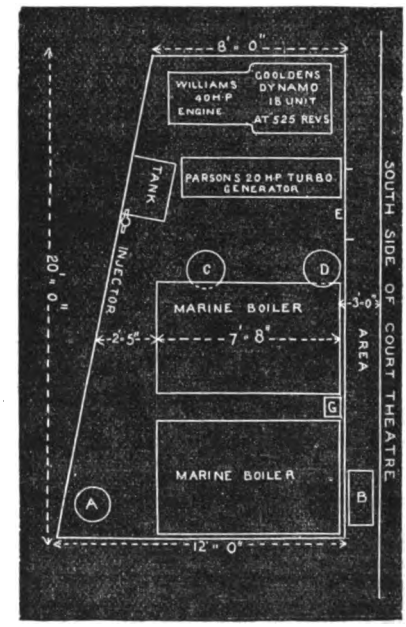
The feed is drawn from a tank and forced through a feed-water heater into the boilers by a donkey pump placed between the two boilers and arranged to communicate with either or both boilers. Each boiler is also fed by an injector. The steam passes through a separator from the boilers before entering the cylinders of the engine running at 525 revolutions per minute.

After the plant was erected and running, the roadway was reinstated in iron work and concrete; the driver and stoker were then completely boxed in, the only access being by a ladder into an area and through a door 4ft. high: a coal shoot at the far end admitted some little air; but daylight was quite absent.

The steam and exhaust pipes are all of copper.

It will not, of course, for an instant be supposed that the electric lighting plant was placed in this position from choice, still it is only fair to Messrs. Sharp and Kent to state the reasons which restricted the available area to so small an amount. The reasons are briefly these:—It had been intended to supply the theatre by electricity from the mains of a public electric supply company. As, however, the Company in question did not make satisfactory progress in the matter of laying mains, it was decided, two months before the opening of the theatre, to put down generating plant on the premises. Then it was discovered that as no space had been allotted for this purpose, and as no space could be spared, the only way out of the difficulty was to excavate under the roadway, and place the machinery underground. Then it was found that the only available spot was bounded on one side by a main sewer, on the next by property belonging to the District Railway, on the third and fourth sides by theatre buildings; and thus Messrs. Sharp and Kent found themselves face to face with the problem how to place the steam and electrical plant in duplicate for about 350 eight candle-power lamps on 200 square feet by 8ft. high. It has been done, and, all things considered, has been eminently successful, for no complaints are made by the management as to the intensity of the light, nor are any serious mishaps reported.

From time to time the number of lights in the theatre has been increased, until for several months past the nightly output has been over 20 units, or double the amount for which the plant was originally put down. This throws considerable strain on machinery running in a temperature of 110° to 112° F., and exposed to coal and ash dust.



Plan of Engine-room at the Court Theatre. Scale, $\frac{1}{8}$-in. = 1 foot.

A, Coal shoot; B, Chimney shaft; C, Steam separator; D, Feed-water heater; E, Doorway, 4ft. 7in. high; G, Double-cylinder pump. Underground height, 8ft. 6in.

Small available space for machinery does not only call for considerable ingenuity on the part of the engineer as to the disposal of the various parts of the plant in the area at his disposal, but it implies difficulties in maintenance which it is not always easy to foresee. A problem of this description is by no means solved when all the machinery has been packed in its place, due regard must be had to facilitate access to working parts so that they can be exposed, if necessary, for inspection or repairs. Thus the test of an engineer is not merely that he has done what is required, but that the arrangement is such that future possible contingencies are as far as possible provided for, so that the plant may, with proper care and supervision, be made to work always at its proper efficiency. Messrs. Sharp and Kent have been very happy in their choice of boilers and engine, and the plant is fairly "get-atable" for cleaning and so forth.

It is especially worth recording that Messrs. Sharp and Kent only received the order to proceed two months before the opening of the theatre, that boilers, engines, and dynamos had to be manufactured specially to suit these unusual conditions, and that everything was done and the plant started within the specified time, namely, six weeks from the date of the order. Above is a sketch plan of the installation, which will give some idea of the difficulties encountered and overcome.

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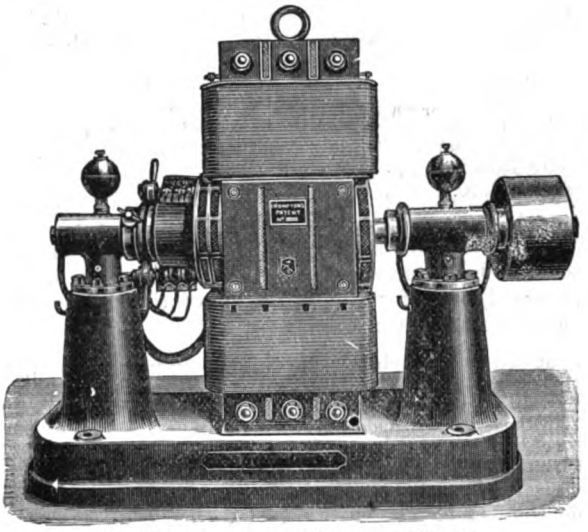
Covent Garden Theatre.—There is an interesting primary battery installation supplying the smoking lounge with light at this theatre. The batteries belong to the Weymersch Electric Battery Syndicate. There are 39 eight-candle power lamps in the lounge and the necessary plant consists of 16 six-cell batteries placed in the cellar. Quite recently the report of Messrs. Alabaster, Gatehouse and Co. appeared in the electrical journals, in which a full description of the battery and method of working was given, so that it is unnecessary to enter into such detail here. This installation is worth mentioning in that it is successful, practically and commercially. So many primary batteries have been taken up by influential syndicates and have all died natural deaths, that technical men may be forgiven for being sceptical on the question of the commercial possibility of electric lighting from primary batteries. There seems to be no doubt, however, from the figures contained in the report, that temporary electric lighting on a small scale can be produced more cheaply by this battery than by gas engines and dynamos.

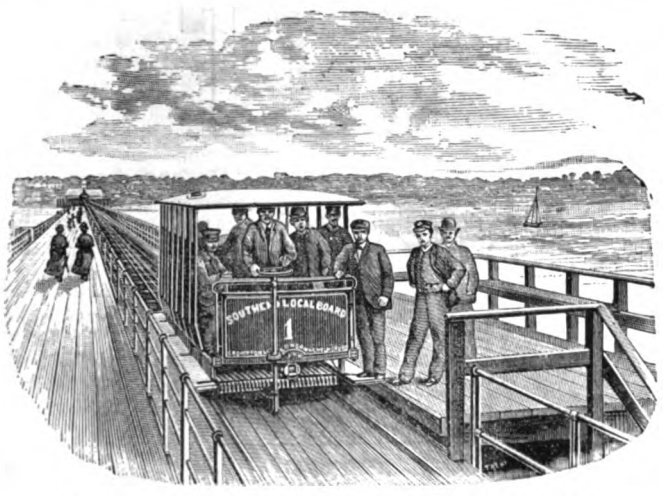
[The author might have taken into account the great saving effected by the absence of dirt and tarnishing of decorations in making his comparison. This alone, to say nothing of the less calculable advantages of coolness and reduced fire risk, enables the cost of the plant for a theatre to be paid for in a few years. —Ed. *E*]

THE SOUTHEND ELECTRICAL TRAMWAY.

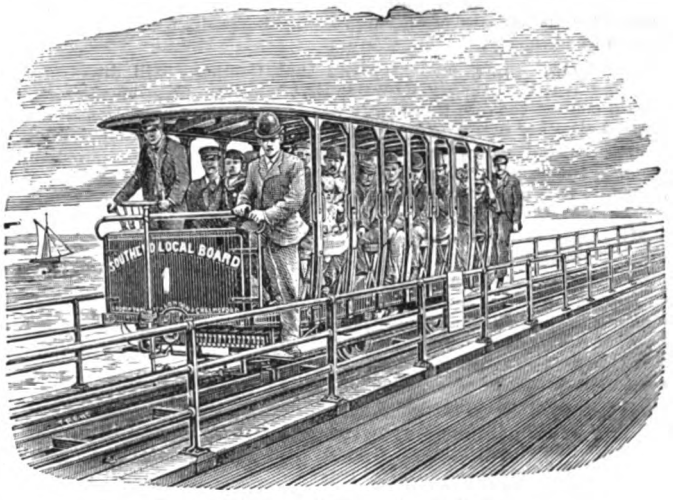
The interesting features of this tramway are the despatch with which the work was carried out, and the means by which this was accomplished, by using material from stock. The Southend Local Board, which is following the example of the enterprise of other watering places in spending money on local improvements, recently replaced the long wooden pier by an iron structure, at a cost of about £80,000. To keep things up to date, it was decided to furnish the new pier with an electrical tramway. Tenders were invited, and the contract was secured by Messrs. Crompton and Co. Three-quarters of a mile of track was laid the car built and fitted; a horizontal compound engine by Davey Paxman, with a boiler of locomotive type, was provided, and the connecting cables were laid so smartly that the tramway was at work in six weeks, and succeeded in earning on Bank Holiday the satisfactory "traffic receipts" which we mentioned last week. The dynamo is of the Crompton standard type, and is compound-wound for 150 amperes at 200 volts. The conductor on the pier is of the ordinary 1in. by ·134in. copper strip, which is used for street mains; and the supports, insulators, and straining gear have been taken from stock, and are identical with those used in 30 miles of streets in Kensington, Belgravia, and Notting Hill. The insulators are placed at intervals of 15 yards, and straining gear with volute springs are placed at every 85 yards. The track is of 3ft. 6in. gauge, the rails being of Vignolle's type. The conductor is laid about 12in. from one of the rails, and 1in. below the level of the rail tops. The rails are used for the return. The motor is a stock pattern; it is speeded down by simple spur gearing as 3 to 1. At both ends of the car are handles for starting and reversing, with an ordinary brake. While 20 miles an hour can be attained, the car runs generally at 12 to 14 miles an hour, the trip being made in three or four minutes, instead of 15 minutes with horse cars. The current is collected by rubbing contacts designed by Mr. Chamen, to whom, with Mr. Scott Moncrieff, special credit is due for the prompt execution of the work. Dr. Hopkinson, as consulting engineer to the Local Board, expressed great satisfaction with the work, which is much appreciated by the residents. The power required for propelling the car is considerably below that which was expected; and Messrs. Crompton and Co. hope to make measurements of the tractive force, and intend to publish the results of their experiments.



Crompton Dynamo; 150 amperes, 200 volts.



End View of Car, three-quarters of a mile down the pier.



Car travelling at sixteen miles an hour.

THE LANE FOX PATENTS.

We have received the following from Mr. Erskine, the hon. sec. of the Defence Association, whose offices are at 148, Brompton Road, London, S.W.:—

TO THE EDITOR OF THE ELECTRICIAN.

I enclose a circular letter which I have sent round to a large number of firms interested in electric lighting, and I should be greatly obliged if you could find space for it in your next issue, as it will then reach some interested with whom I have been unable to communicate.

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THE LANE FOX CLAIMS.

SIR: In further reference to the above, a meeting was held on the 13th inst., at which several of the principal members of firms and others engaged in electrical engineering were present, and it was resolved to form an association for mutual defence against the Lane Fox claims. At this meeting ten firms signified their adherence.

You will see at once from the fact that the above number of firms have agreed to join the Association, that the Association has already received large and influential support; but it was the general opinion that all those interested in the matter should be allowed the opportunity of joining the Association on the original basis as proposed in my circular letter of the 22nd July. I was, therefore, instructed to ask you to let me have your definite reply on this matter not later than the 30th August.

In naming a date for your adherence, I beg to call your attention to the fact that we are on the eve of various attacks on the electrical trade in the shape of attempted monopolies, and that it is of the greatest importance that it should be at once seen that the *whole* trade are alive to this, and are prepared to resist immediately any unfair interference with the progress of the electric light industry.

August 15, 1890.

In reference to this matter, the following letter was sent out on the 22nd July last, accompanied by the circular setting out the proposed basis for the formation of the Defence Association, which is also given below:—

Your attention has perhaps been called to certain claims which have recently been put forward by the Lane Fox Electrical Company (Limited), with regard to the system of distribution by means of secondary batteries in conjunction with dynamos. The Lane Fox Company claim the exclusive use of this system by virtue of the patents granted to Mr. Lane Fox in 1878, and they are demanding royalties accordingly.

Amongst others against whom the claim has been made is my Company, and my Directors have therefore caused the matter to be investigated, and have obtained an opinion from their technical and legal advisers as to the validity of the claim. The result has been to satisfy them that the claim cannot be sustained, and they therefore propose to resist it.

The case, however, is obviously one in which successful resistance on the part of any one defendant will enure for the benefit of all who are making use of the system; and it appears to my Directors that it would only be prudent and expedient that all concerned should co-operate in the defence. They have therefore instructed me to communicate with you, and with others whom they believe to be interested, with a view of forming an association for the purpose of offering combined opposition to the claims of the Lane Fox Company.

It is not yet known against whom that Company will direct its first attack, but it is obviously desirable that whoever may be thus selected should contest the case thoroughly so as to secure a decision which will protect all other users. The question interests alike the supplying Companies, the contractors who do electrical work, and the private individuals who use the system in their private installations, and it appears to my Directors that an opportunity of co-operation should be given to all concerned.

My Directors have already opened communication with several of the other Companies interested, and two or three of them, including amongst others the Westminster Electric Supply Corporation (Limited), and Messrs. Crompton and Co. (Limited) have promised to co-operate. Further, the opinions of Sir Frederick Bramwell, Mr. Swinburne, and Mr. Kapp have been obtained, all of whom agree in advising that the claims of the Lane Fox Company cannot be sustained. Those opinions have been submitted to counsel on behalf of my Company, and counsel's opinion is to the like effect. My Directors, therefore, feel justified in believing that the claims could be resisted successfully, and they think this could best be done by the formation of an Association upon some such basis as is indicated in the terms set out on the enclosed paper.

I am now instructed to ask whether you will be prepared to join such an Association. You will observe that it would not commit you to a larger expense than £... unless after consideration of the matter in general meeting you should be willing to carry your liability further.

Probably it will be found convenient, if a satisfactory number of adhesions should be received, to form a small Committee to represent the Association and direct any proceedings which may be taken for the common benefit, it being always understood that neither the Committee nor the Association itself should have the power to compel the continuance in the Association of any member who desired to withdraw or to impose upon such member any pecuniary responsibility beyond that which the member might actually have agreed to undertake.

My Directors would be willing to give the Association the use of this Company's office for the purpose of carrying on the work, so that no expense need be incurred except such as may be incidental to the employment of technical and legal advisers, and such printing and stationery as may be necessary.

It would be well to get the Association formed without delay, and if possible before the commencement of proceedings by the Lane Fox Electrical Company (Limited). I shall therefore be glad to be favoured with your views on the subject at your earliest convenience.—Yours faithfully,

R. S. ERSKINE, Secretary,
The Kensington and Knightsbridge Electric Lighting Company (Limited).

To.....

PROPOSED BASIS FOR THE FORMATION OF A DEFENCE ASSOCIATION.

An Association of Companies, Firms, and Persons using secondary batteries as accumulators of electrical energy in connection with the supply of current from dynamos, for the following objects:—

1. To defend any action that may be brought against any of them by the Lane Fox Electrical Company, who are threatening to commence actions in respect of the letters patent owned by them, and alleged to cover the system of supply above mentioned.

2. To take such advice, and collect such information, as may be necessary for the protection of the rights of the several members of the Association to use the system of supply above mentioned.

3. Supply companies to subscribe a minimum of £50, contractors £25, and owners of private installations £10, to be called up as required; this would entitle members, thus constituted, to claim that the Association should defend any action to the extent of the funds subscribed, and any additional amount which may, from time to time, be voted in general meeting, which might be brought against them by the Lane Fox Electrical Company, in connection with the above-named claims.

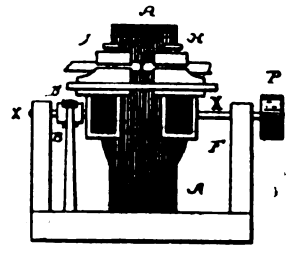
4. Should further funds be required, the members are to be called upon to subscribe in the ratio of the sums above mentioned, according to their respective denominations.

5. Any member of the Association may retire at any time, in which event this Association shall no longer be under any liability to defend any action which may have been brought, or may be brought against the member in question.

A NEW WELDING DYNAMO.*

The accompanying figures represent a new dynamo recently designed by Prof. Elihu Thomson. This machine was devised with a view of securing great compactness, and to enable the welding currents to be carried directly to the work without collecting brushes.

FIG. 1



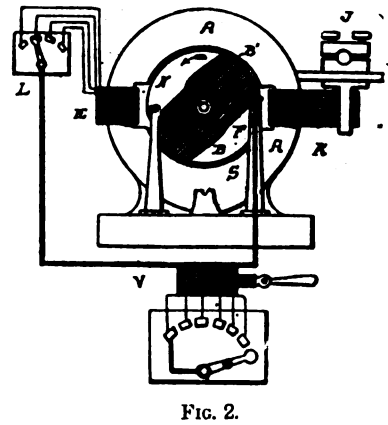


FIG. 2.

The chief feature of this generator consists in the employment of a revolving field-magnet, a stationary coil in which currents are developed by the revolution of the field-magnet for supplying the exciting current of the machine, a second stationary conductor in which the heavy welding currents are developed by the revolution of the field-magnet and a commutator on the shaft of the field-magnet for commuting the exciting currents before they reach the revolving field coils.

Regulation is secured, first, by governing the current supplied to the work by means of a coil of variable reaction or self-induction interposed in the circuit of the exciting current between the exciter supply-coil and the commutator, so as to be traversed by the alternating currents before they are commuted to pass through the revolving field-magnet as a straight or unidirectional current.

The general design of this machine is represented in the figures. Fig. 1 is a side elevation and Fig. 2 an end view of the generator.

* From the *Western Electrician*.

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In the diagrams N S are the poles of the revolving field-magnet, resembling in form an armature of the Siemens shuttle type. A A is the iron of the armature, which is here represented as a laminated ring with spaces cut away for the exciter supply coil E and work supply conductor K. A commutator of two half circles with brushes B B′ has its segments connected, respectively, with the terminals of the field coil F. The brushes are connected respectively with the appropriate terminals of the exciting coil E. Interposed in the exciter circuit is a variable self-inductor V. The work supply conductor K terminates in two clamps J H for holding pieces of metal to be welded. The work-supply conductor K consists of one turn, or two or three turns around the armature core A A. The exciter supply coil E is wound in sections, and a switch L is used to vary the number of sections included in circuit for use. During operation the current, which is generated in E and excites the field, is varied by V, so as to control the potential and current of the work supply conductor K.

HIGH SPEED IN ENGINES FOR ELECTRIC LIGHTING.*

Although Watt was not "the inventor of the steam engine," as the great improver and introducer of the engine he deserves all the honour that later generations have accorded him. The invention of the details of the modern engine was sufficient to entitle him to all this, even had the machine done vastly less for the race than it has actually accomplished; but the benefit conferred was largely through the action of secondary and resultant developments.

Since the days of Watt there has been no industrial development even approximately as important as the now familiar and almost matter-of-course introduction and extension of the various applications of the power of steam through the intermediary of the electric current. The growth of steam engineering during the last decade or more has been almost as great and as wonderful as during the earlier days of the development of the Watt engine. The use of the electric light and of electric power transmission, as in the use of motors and on street railways, and the many minor applications of electricity have compelled the expansion of many old lines of business most remarkably, and have accomplished even more remarkable things in the institution of new kinds of production.

The maker of wire has been forced to seek the finest and purest copper, and to draw it into wire, harder, stronger, and in greater lengths, than it was ever before supposed possible to secure; new kinds of insulation, new systems of support and of preservation, have come into use, each improvement bringing after it a long train of minor or accessory inventions, discoveries, and improvements. Innumerable new forms of dynamo-electric machines, each specially and precisely adapted to a certain prescribed purpose, generators and motors of once unimagined perfection and efficiency; with, for each one of them, a host of little improvements and inventions in detail, have set the world agog with their work, have made the engineer wonder at their ingenuity, and have puzzled even the man of science and the professional electrician by the delicacy and subtlety of their theory, and by the variety and singular characteristics of their interacting currents and forces.

Finally, the steam engine itself has been given new forms to meet the requirements of this imperative new master. We propose briefly to consider the latest modifications of the engine, giving a concise and untechnical account of its special peculiarities, and the principles of its construction and application, as dictated by the new purposes to which it is sought to apply it.

There are two principal characteristics that distinguish the machinery employed for electrical distribution of energy from most other kinds of apparatus driven by the steam engine. The speed of rotation is unusually high, and the regularity of its motion, to insure satisfactory results, must be made extraordinarily perfect. To these two essentials all other considerations are subsidiary. In the various forms of machinery employed in the arts, outside this department, the first demand of the prime mover is generally economy of operation, and the exactness of its motion is a secondary, though often important desideratum. In the most exacting work, that of cotton machinery producing fine goods, it has been thought that the regulation of the engine driving it should be made sufficiently perfect to keep the fluctuation, with usual variations of loads, within about one per cent. of the mean, and within a total range of two per cent.; but, in electric lighting machinery, the range considered allowable is oftener half these figures, and some makers guarantee that the fluctuation shall be imperceptible, from full load to no load. The usual speed of the main line shafting in mills and in shops is rarely above 200 turns per minute, while, in the dynamo, the range is from about 1,000 on those of moderate size and of special types, up to 2,500 and 3,000 in extreme cases; while some are constructed to turn very much faster than the latter, even. The engine demanded of the trade for these latter purposes, therefore, must be capable of regulation to within perhaps one-half the range of the older types, and must be fitted to couple directly to machinery having five or ten times the speed of rotation of ordinary mill machinery. This demand, exacting as it is and seemingly impossible to meet, as it would have been thought not many years ago, has been satisfactorily fulfilled by a number of inventors and constructors.

The difficulties to be encountered in the attempts to comply with such conditions can hardly be realised by those unfamiliar with the steam engine and its development. It was at once evident that the speed of rotation must be increased, and the ideas of Charles T. Porter, who had, as early as 1860, shown that speed is an element of economy, and had begun to exploit a "high-speed" engine, seeking economy in that manner, were recognised as elements of the new form of engine. In the days of Watt, the speed of rotation had rarely, even with small engines, exceeded 50 revolutions per minute; and Mr. Corliss considered that a speed of 75 revolutions was about as high as his tripping mechanism would ordinarily allow; but Porter went up at once to 200, and the Corliss engine is now sometimes driven at over 100 revolutions per minute. The modern high-speed engine goes far above these figures, however, and 300 revolutions is thought a very fair, but not radical, limit. In a few cases, as in engines of Ericsson and others built for special applications, this speed has risen to as high as 1,000, and even, with very short strokes of piston, experimentally to over 2,000.

Some of the conditions of success in the attempt to solve this great problem are sufficiently evident. The obviously essential high speed of rotation of such engines can only be attained by simplifying the construction of the machine just as far as practicable, and by discarding the "trip cut-off" and adopting some "positive motion" valve gear. But the trip was considered the vital element in the regulating mechanism of the older engines, as it allowed the governor to do its work without introducing irregularities in its action through resistances coming from the valve motion. Porter adopted a "positive" and then secured good regulation by the use of the powerful loaded governor, in the form now so well known by his own name. Hartnell and Guthrie, the inventors of the device in England, and Hoadley, the first to use it in this country, by adopting the now almost universally employed "shaft governor," gave to all later makers the means of solving this problem most satisfactorily, enabling them to use the simplest possible valve gear and yet to obtain a good distribution of steam and the most perfect regulation at the same time—conditions formerly considered absolutely incompatible.

It is practicable to make the "detachable" valve gear operative up to speeds even exceeding 100 revolutions per minute; the shaft governor is adapted to velocities of 200 turns and upward; the higher the better. At 300 revolutions a minute, a common speed with this class of machine, it is possible to regulate, by nice adjustment, to within a range of one-half of 1 per cent. This has been attained in engines tested by the writer, and may be attained by careful manipulation of the best high-speed engines of almost any well-known makers. This solves the second of the prime requisites—the first from the point of view of application, perhaps—that of exact regulation. No system of electric lighting can be satisfactory in which the fluctuation of speed of engine can be observed at the lamp, in its varying intensity. Such fluctuation cannot be perceived where restricted to a fraction of 1 per cent., nor can it practically interfere with good work when kept well under 2 per cent., the once accepted limit.

Economy comes in as a third requirement of the new type of engine. The older "simple" engines were expected to give the horse-power on an expenditure of not more than three pounds of good coal per hour, if non-condensing, and about two pounds if condensing; which corresponded to about twenty-five or seven pounds of steam for the first, and perhaps twenty pounds for the second class, with the best modern boilers, economisers, and heaters. But the older types of engine had a great advantage in their admirable systems of valve-gearing, which gave an equally excellent steam distribution; the separate steam and exhaust valves, separated ports, and quick cut-off all conspiring to enable the engineer to secure the closest possible approximation to the perfect ideal which is essential to maximum efficiency. The use of a single valve, in the high-speed engine, restricts him very seriously, and compels a certain loss of efficiency. From 30 to 50 per cent. more steam was thus at first used in these engines. Good proportions of valve and of gearing, ample high speed of rotation—itself an element of economy—and practically frictionless and "isochronous" governors were brought out; but the machine still remained a less economical heat engine than the older type, and, in most instances, seriously so. The source of this waste and the methods of its prevention were promptly made the subjects of investigation, and the wonderful inventive faculty of the American engineer was set at work to devise improvements.

* Abstract from a Paper by Robert H. Thurston, Director of Sibley College, Cornell University, in the *Electrical World* of New York.

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The cause of waste was very quickly detected in the large amount of "internal condensation" or "cylinder condensation," as it has come to be called, which was consequent upon the high heat-conducting power of the metal of which the cylinder is composed, and the exaggeration of this loss which comes from the increased proportion of surface exposed to weight of steam passed through the engine, as sizes are diminished. The increased speed of engine had diminished its size for a given power, and this had, in turn, with the less effective steam distribution, produced a large percentage of waste. The amount of this loss varies, in ordinary good practice, from about 25 or 30 per cent. in an engine of about 200 indicated horse-power, to 40 or 50 per cent. with engines of 50 horse-power of the same make, and to 60 or 70 per cent. in engines of from 1 to 5 horse-power. The remedies previously found effective in the prevention of waste were, however, well understood, and were promptly put into practice by the more enterprising builders. These are three in number: 1. Increasing the work of the engine in such manner that the amount of condensation in the unit of time being given, its proportion to the quantity of steam used in the engine in the same time should be reduced. 2. Superheating the steam, thus reducing its capacity for wasting heat in the engine. 3. Compounding the engine so that the waste of the one cylinder might be utilized in supplying the demand due to waste in the succeeding cylinder.

The first of these methods had been found effective, but the new engine was precluded from resort to this expedient from the fact that it was already constructed for as high speed as was found practically safe and satisfactory. The second device was known to be effective; but, while every builder endeavoured to secure dry steam, with more or less success and without meeting with serious embarrassment, the attempt to use superheated steam had been shown, by many years of experience, to be invariably attended with more or less risk to boilers and engines, and with considerably enhanced cost of maintenance. On the whole, superheating had never become a successful and accepted method of increasing economy, though well known to be in theory and in practice a most efficient means of reducing these internal wastes. A half century of experimental use, under all known conditions, had not given it permanent place among the standard expedients for securing maximum economy of steam and of fuel, even though endorsed by the highest of European authorities, M. Hirn. A few great designers and builders, as Corliss and Leavitt in this country, and Cowper and a few others in Great Britain and on the Continent of Europe, had, in special cases—usually in steam pumping engines—made good use of the device; but these instances were rare, and the system was, and is, but slowly gaining ground.

Compounding, on the other hand, had been practised from the days of Hornblower, the rival of Watt. At first entirely unsuccessful, the gradual rise of steam pressures, the gradual increase of the ratio of expansion, and the continually increasing demand for economy in use of fuel and of steam, gave this system a stronger hold as the years went by, and it at last became, a generation ago, a somewhat common method of construction of large engines for important work, and has now become the universal system in marine engineering and in some departments of stationary engine building, as in pumping engines and the finer class of mill engines of large power. It was not quite understood, however, until recently, by the average practitioner, what were the real causes of its efficiency, and it was not known whether it would pay to employ it in small engines. This last doubt was promptly removed upon trying it, and the "high-speed compound engine" is rapidly becoming the standard engine for its special field of work. It was found that the total gain in the best constructions, due to compounding, amounted to something like one-third on engines of large power, and often to one-half with the smaller sizes. This made the difference between success and failure in many cases, and with a handsome margin on the right side. Nearly all builders promptly took up the system, after the first experimenters had gone ahead.

So far as now known, there are but two ways in which further improvements can be effected. The speed is at a limit beyond which it is expected to go but slowly as methods of construction are improved, and as the attendants become accustomed to management of the new engine; the regulation is as near perfection in the best engines as is either desired or expected; and simplicity of construction can hardly be carried further; indeed, the symptoms are rather that we may see a reaction in the direction of a multivalve distribution in some cases.

The economical use of steam is still far from that indicated by theory as the ultimate. The engine above referred to demanding from 25 to 70 pounds of steam per horse-power per hour, as actually built in the various sizes specified, should, if the ideal conditions could be attained, give its power at the rate of less than 18 pounds. The best engines built to-day, of any type and of highest duty, have an ideal expenditure of about 8 or 9 pounds of steam per horse-power hour, while they actually employ from 13 pounds upwards. The two ways in which these losses, of a third or more, can be further reduced, so far as now known, are increasing the temperature, and, perhaps, the pressure of the steam used, and the production of a non-conducting and non-radiating surface within the cylinder of the engine.

Superheating the steam was shown by Hirn to be the best and most philosophical method, provided it could be made practicable from the constructor's point of view. This has not yet been generally practised, but it is not improbable that it may be done with good design and construction of the superheating apparatus and proper management of the engine. Its use would render the jacket superfluous, as it is known that the latter has no appreciable effect where the steam is kept dry in the cylinder. No wastes are left that it can affect. It would substitute for the disadvantages of the jacket, as a matter of construction, those of the superheating system. The latter have formerly been the greater; but it does not follow that they will continue to be so. A good superheater, and a good cylinder-lubricating system for high temperatures, would accomplish this end. These should certainly be within reach of the inventor and the constructor.

The securing of non-conductivity of the internal heat-wasting surfaces of the cylinder would not seem absolutely beyond our reach. A century ago, Smeaton, the greatest engineer of his day, in part accomplished this result by the use of a sheathing of wood on his pistons and cylinder-heads. This cannot be done with the high pressures and temperatures of steam usual to-day; but other plans may prove feasible. Mr. C. E. Emery, many years ago, tried enamelling these surfaces, and with enough success to show that the idea is a good one; though the enamels and coverings then available were not suitable for this purpose. The writer has found a method patented by him some time since similarly effective and possibly practicable, and doubtless other inventors will turn their attention to the problem, ultimately with complete success.*

Could a material be found of sufficient strength and a good non-conductor, of which the steam cylinder could be made, this result would be reached, and the efficiency of fluid of the ideal engine would be practically attained.

Like the best engines of other types, the modern high-speed engine now seems to have been brought, in its best forms, to so perfect a condition that the range for further improvement is probably very narrow, and the gain still to be made must come slowly and painfully. In regulation and in simplicity of construction, in speed of rotation and in general adaptation to its special work, it is comparatively satisfactory. The further improvement must be in economy of its operation and maintenance. Greater efficiency of the working fluid will be gained, as in all other heat-engines, by increasing the temperature of the steam; higher efficiency of the engine as a machine will follow more effective ways of reducing engine friction; but the compounding of the engine must be taken as the last large economical step in its improvement.

The problems now arising in its application are those which come to the engineer in all departments of his work. He must decide what efficiency he can afford to pay for in increased cost of engine; what size of engine he should adopt for a given amount of work; what size of "unit" of power he may best adopt in dividing up the work, if he is to divide it at all, among several engines, and what each subdivision of power should measure. In general, it is now well understood that the engine should be given a lower ratio of expansion than was formerly supposed economical under specified conditions. The ratio should rarely, probably, be greater than three or four in simple non-condensing engines, and at less than 100lb. pressure, or greater than six or seven in simple condensing engines. Compounding enables the engineer to design his engine with a view to expansion down to a terminal pressure—in the latter case of, perhaps, 10lb.—economically.

The unit of power adopted is made the largest at which the engine can be continuously employed in its regular duties, and for some hours together. Every case, and especially in electric lighting, compels the designer to study the problem from many points of view, and to compute probable expenditures and minima of costs for a variety of possible arrangements, before he can finally safely decide just what system to employ or what type of engine is likely to prove best for the intended establishment and plant. Mr. Field's work at the Edison station in Brooklyn, and that of Mr. Henthorn in Providence, are good examples of this problem, carefully worked out, while the plans of the West End Company in Boston, and many of those produced by Mr. Sprague, illustrate the solution of similar problems in street railway work.

* My plan consists in dissolving the iron from the surface of the parts exposed to the action of steam, as the faces of the piston, the interior of the heads and the ports, by the use of acid, thus leaving a thin covering of reduced conductivity; which surface is then, if desired, filled with a still better non-conductor, as the resin of a drying oil, with which it may be saturated. The experiments of Prof. R. C. Carpenter and of Mr. P. M. Chamberlain indicate that this may effect a saving of a large fraction of the now seemingly unavoidable interior wastes.—*Transactions* Am. Society of Civil Engineers, 1890 (Cresson meeting).

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SOME DEFECTS IN PHYSICAL TERMINOLOGY.*

BY PROF. A. E. DOLBEAR.

Whewell attributes the failure of the Greeks to make headway in physical science to the fact that their ideas were not appropriate to the phenomena. In a like manner it may be said that we are retarded by the lack of appropriate terminology, and that something will be gained when the terminology is so far reconstructed as to be incapable of misleading one.

As to the nature of energy. In Daniell's "Textbook of the Principles of Physics" the statement is made that "energy is a physical entity," implying that it is an independent, objective something, an existence not conditioned by other physical things, and this idea is so common that it is worth while to closely inspect it. Now, energy is defined as the ability to do work, and work is measured in foot pounds. When we give expression to the relation between energy and work we have, $\frac{M v^2}{2} = W h$, when M is the mass, v the velocity, W its weight and h the height to which W will be raised. But $\frac{M v^2}{2}$ is the measure of energy in the units of work. In absolute units it is proportional to $M v^2$, or, as it is perhaps better to write it, $M v \times v$, which is the velocity of momentum. As there is no such thing known as energy where there are not two factors, namely, a something—a real entity—and a motion, it follows that when there is absolute quiescence there is no energy; and if there be no substance, though velocity be infinite, there is no energy. Hence energy is a *product*, and is not a something that exists apart from moving bodies. It is a product of substance and motion, and is proportional to the amount of motion.

There is, then, no good reason for considering energy as being a mysterious something that has an existence apart from the substance of the physical universe any more than there is for considering the same for motion or for momentum.

It appears that the so-called forms of energy depend upon the form of the motion involved as well as the character of that which is moved. As to the first of these, the kinds of motion that are possible are probably very great in number, but they may all be reduced to their primary forms, namely rectilinear, vibratory and rotary. Combinations of these yield all sorts of others. For instance, two rectilinear will give either a resultant rectilinear, as exhibited in the so-called parallelogram of forces, or a curvilinear, as in the movement of a bullet fired from a gun in other than a vertical direction. A combination of a rectilinear with a vibratory gives an undulatory or wave motion; a rectilinear with a rotary gives a spiral, and so on.

The expression for the energy of a body is not limited by the size of the body. It is as applicable to an atom as to a cannon ball or the earth in its orbit, but it is convenient to change the form of it where the physical conditions warrant it. For rectilinear motions or combinations of them the form $\frac{M v^2}{2}$ is used for both large and small bodies, only such motions of atoms and molecules are called free paths, or the distance between successive impacts.

For vibratory motion, however, the value of v depends upon two conditions, the number of vibrations per second, n, and the amplitude of the vibration, a. These are entirely independent of each other, and either may have almost any assigned value, so that $v = a n$, and the energy is $\frac{M a^2 n^2}{2}$.

For a rotating particle, energy $= \frac{M r^2 \omega^2}{2}$, where r is the distance to the centre of rotation and ω is the number of degrees passed over in one second. It may have substituted for it the expression for rectilinear energy by making v the number of feet passed over in a second.

When the moving body is so large that its motions may be seen, the body is said to have mechanical motion or mechanical energy, sometimes kinetic energy, and when the body is too small to be seen the movements are spoken of as atomic or molecular; and here is where trouble often begins, by failing to keep in mind that the size of a body makes no difference in the character of the motions it may have.

For twenty-five years or more we have been familiar with the expression, "Heat is a mode of motion," and lately we have it in numerous works intended to be exact that "Heat is a form of energy." To illustrate the foggyness upon this matter, I cannot do better than to quote statements from several text-books lately issued. In Daniell's "Principles of Physics," p. 325, there is the definite statement in large print, "Heat is a form of energy." On p. 326 is this statement, "Heat is not motion;" and on p. 444, "The molecular vibration which excites ether waves is a true vibration of the molecule, not a translational oscillation from place to place." Olmstead's "College Philosophy" (Kimball's revision) has it, "There is abundant reason for believing that heat consists of exceedingly rapid vibrations of ordinary matter and of the ether which fills all space." In Avery's "Elements," "Heat is a form of energy. It consists of vibratory motions of the molecules of matter." In "National Philosophy," by Sharpless and Phillips, "Heat like light consists of waves of ether." In Gage's "Elements of Physics," "Heat is molecular motion." In "The New Physics," by Trowbridge, there is the statement that "motion is therefore being continually changed into heat in all the operations of machines." Also, "The phenomena of heat and light are so closely allied that it is impossible to regard them as separate manifestations of energy."

Maxwell says: "Heat is of the same nature as mechanical work, that is, it is one of the forms of energy." Also, "We have no right to speak of this process of radiation as heat;" and again, "Heat can be generated and it can also be destroyed." "For every foot-pound of work so done, a certain quantity of heat is put out of existence."

These quotations are quite sufficient to show that there is no agreement among authors as to what the nature of heat is, nor is there always consistency in the treatment by a given author. There are the contradictory statements that heat is a mode of motion, and that it is not motion—that it is energy, and that it can be destaoyed; that it is ether waves, and that ether waves cannot properly be called heat.

Let it be admitted that a heated body sets up what we call undulations in the ether, that these waves have a wave length determined by the period of vibration of the atoms or molecules, and that the energy of the ether waves varies as the square of their amplitude, and let it be also admitted that there is not the slightest evidence that translational motion of a body of any size sets up waves in the ether, and it follows at once that what we call heat is the true vibration of the molecule and not its translational motion. That is to say, heat is the vibrational motion of atoms and molecules and its energy is proportional to the square of the amplitude of vibration.

If translational motion could impart to the ether any motion, of course a proportional part of energy would be observed by it, and the earth and other bodies moving in it would be slowing up. Now the velocity of the earth in its orbit is something like 17 miles a second, but the velocity of a molecule of hydrogen, the swiftest of all molecules, at 0°C. is but 1,843 metres, or only about $\frac{1}{18}$th that of the earth; so, if the earth movement sets up no waves, the free path of the gaseous molecule can much less. Again, the whole of spectroscopy teaches the same thing, namely, that the ether waves are set up by the internal vibrations of molecules, and not by their external motions. As no other kind of motion is known that can produce similar effects, it would seem to follow that heat will be correctly defined when the character of the motions are specified.

When motion of one kind is transformed into another kind, the character of the energy is transformed also, and what a given amount of energy will do depends altogether upon its form, not upon its quantity; that is to say, vibratory energy has possibilities that do not belong to rotary or rectilinear. There is the assumption that heat exists in three forms: 1, the true vibration of the molecule; 2, the translational free path motion; and 3, the ether undulation when as both the translational motion and the ether waves are the results of the vibration of the molecule, the one by impact, the other by absorption; the one a transformation of vibrating into rectilinear free path motions, the other both a transformer and a transformation. To call each of these by the same name is to confound entirely different phenomena—an effect with a cause.

In every case where there is a so-called transformation of energy, what really happens is a transformation of motion, hence if the various forms of motion have specific names the inconsistencies will all disappear.

It is but a short time ago that we were taught that there were three kinds of radiations from heated molecules—heat, light, and actinic rays; but photography and the bolometer have rendered that statement quite untenable, for it has been discovered that what ether waves will do depends upon what they fall upon. One body will have its temperature raised, and we say it is heated; another body has its molecular structure broken up, and we say it has been chemically acted upon; and still another has a sensation incited, and we say it is the effect of light. Now that light is known to be a purely physiological phenomenon, and that there is no such thing apart from eyes; and even with the probability that what goes on in the eye itself is of the nature of photographic action, the general explanation of all the phenomena has been changed, but the terminology remains to mislead even those who are more or less familiar with the facts, as when one speaks of "the velocity of light," of the existence of "dark and light heat rays," and of the "temperature of space." If light be a physiological phenomenon, it cannot at the same time be an undulation in the ether; neither

* Abstract from an article in the *Electrical Engineer* of New York.

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can dark and light be applied to the same phenomenon, nor can empty space have a temperature, as temperature is a condition of the molecules of matter. The term "radiant energy" has sometimes been used as a substitute for radiations, and in Daniell's "Physics" the whole range of undulatory motions in the ether is treated under the general head of Ether Waves. This is better than the other; yet between these two there is this discrepancy, that motions of any sort cannot properly be called energy, for, as said before, energy is a product and motion is but one of the factors.

In the subject of electricity the lack of definitions in the terminology has led to a great deal of confused thought, but our actual knowledge of the character of electricity is much greater than many suppose it to be. Maxwell and others have asserted that whatever it may be it is not energy, while others, as represented by Preece, assert that it is energy. Curiously enough, Maxwell declares that it cannot be energy because electric energy is a *product* of electricity, E, into a current, C.

Edlund and some others have thought electricity to be identical with the ether, while still others have imagined it to be a fluid, or two fluids, or some kind of matter with the fundamental property of matter, namely, *mass*, left out. It is not very difficult now to see how such varied conceptions arose. An electrified body affects the space about it, or, as we now say, it produces an electric field which is known to be a stress in the ether, and that implies a strain in the electrified body. It is also known that such stress is propagated in the ether with the common speed of ether waves, namely, 186,300 miles per second. The speed of this movement has been measured by so many and in so many ways that there is no doubt about it, and since the experiments of Hertz there is no room for doubt as to the existence of the ether.

What we now know is that states of stress in the ether are propagated at a definite rate in it, which rate depends not upon the source of the movement but upon the property of the ether to transmit movement; so, whether heat movements or electrical movements are antecedent makes no difference. We find no difference in perceiving the relation between the vibratory molecular motions and the resulting waves in the ether, but here is a precisely analogous case of electrified molecules and the ether propagating a motion, which implies, if anything, that molecular motion is the source of the ether displacements. One person will give chief attention to what is going on in the electrified matter, and another person to what is going on in the ether, and they come to different conclusions as to the nature of electricity, while a third person who notes their discrepant notions concludes that no one knows anything about it. What we call electricity originates in matter, and there is no evidence whatever that it ever originates apart from it. As Rowland has somewhere said: "It begins in matter and ends in matter." The conditions for its origination are differing and interfering molecular motions, whether in a thermopile, a galvanic battery, or a dynamo; the conditions for its transference are a continuous material conductor, for it cannot traverse a vacuum. The effect upon the ether we call an inductive effect; and just as in heat phenomena we have a transference and a transformation, so is there also in electrical, both a transference and a transformation. In heat phenomena, where matter is placed in the thermal field so that the ether undulations fall upon it, the matter is heated. Likewise, when matter is placed in an electric field the matter is electrified. The cases are exactly analogous, and one is therefore justified in making the terminology appropriate to the phenomena; and whenever there has been a transformation in the motion, another name ought to be adopted and not let the old one do double duty. If molecular motions of any kind be called electricity, then it is not proper to call any effects in the ether by that name. If the effects we study in the ether be called electricity, then do we need a name for what takes place in matter, for one is the effect of the other.

If one adopts the doctrine of the conservation of energy, and also that the matter of the earth is practically a constant quantity, it will lead him to conclude that all the varieties of energy are due to the various forms of motion that matter may have. If, also, one perceives that motion of any kind, at any place, implies antecedent motion, he will not feel the necessity for looking for hyperphysical explanations for any physical phenomena. For instance, when one sees the light and feels the heat from an electric arc lamp, knowing the nature of both the light and heat as being but particular forms of motion—one in matter, the other in the ether—he could logically look for nothing but some kind of motion that had been transformed to produce such effects. It is entirely immaterial what the character of the motions may be that produce electrical effects—that may remain to be determined by experiment—just as in the case of heat after the work of Sir Humphrey Davy and Count Rumford, it was then settled what the *nature* of heat was, namely, a molecular motion of some sort and not an entity. It is only within a few years that the character of the motion has been determined. In like manner, we may say that we know what the *nature* of electricity is—that it is also molecular motion of some sort to be experimentally determined

There are numerous reasons for thinking it to be a rotation as distinguished from a vibration. One of the chief of these comes from a study of electro-magnetic effects in the ether. It is generally agreed that this magnetic effect in the ether is of the nature of a whirl, or rotation, and in numerous treatises these whirls are pictured, but I no not remember to have noted that anyone has pointed out that a whirl in the ether implies a rotation of a molecule, for a similar reason that an undulation in the ether implies a vibration of the molecule. To me this appears to be necessary, but whether the motion be that or some more complex kind does not so much matter—it will be discovered in time.

There is one more important matter I want to allude to, and that is the expression first used by Maxwell, namely, "Light as an electro-magnetic phenomenon." Waiving for the time the criticism that light, being a physiological phenomenon, is therefore inappropriate here, there still remains this fact, that the ether waves from heated bodies move in straight lines, and unless deflected by the reflections and refractions of matter will continue indefinitely on in the same straight line, making the field of a heated body as extensive as the universe; while the field of an electrified body depends upon the proximity of masses of matter, and practically is always limited in extent, and the observed lines are always curved. So if the two kinds of waves were really parts of the same movement, what is called a ray of light would seldom or never be found to move in a straight line for any considerable distance. If, on the other hand, the wave that originates in a vibration continues in a straight line only so long as it moves in homogeneous ether, and has its place of vibration changed by passing through a space of ether that has been electrically warped, as we experimentally discover to be the case, it would seen to follow that the two kinds of motion in the ether are fundamentally unlike. Either can exist without the other, and therefore they ought not to be called by the same name.

MODERN CONCEPTIONS OF ELECTRICITY.*

BY DR. LOUIS DUNCAN.

The electrician is mainly concerned with the transformation of energy, and material only affects him as it modifies these transformations. The principal virtue of electrical applications lies in the ease with which they allow transformations otherwise difficult to be made. For example, I have here some pieces of apparatus which will illustrate this,—motor, Geissler tubes, piece of carbon, induction coil and jars. What we want to understand is how this transmission takes place.

For the last half-century the great advances in physical science have been through the application of the law of the conservation of energy. Energy disappears at one place and appears in another form, perhaps in another place. The two quantities are equal, or if they are not equal the difference must be accounted for by some loss which must be discovered. The law leads readily to equations, and these have given results of great importance. But, in the last few years the attempt has been made to trace the path of the energy, which leaving one place appears at another. We try to label a given portion of energy—the energy in a given piece of coal, say—and to follow it into the boiler, and then to the engine, and then, perhaps, to a dynamo, and finally, as electric energy to this electric lamp. It has suffered a number of changes, it has passed through many forms, but, finally, that individual portion of energy has reached the lamp, and being changed into radiations, has started on a journey causing a shudder of the ether through the universe and reaching the confines of space.

It is by tracing these various actions that we have arrived at our present notions, and we have traced them backward, beginning with the energy after it has become radiant.

Ever since the undulatory theory of light began to be held, it became evident that there must be some substance, pervading all space, which would transmit the vibrations which constitute light. It is evident that if light is vibratory, something must vibrate, and as there is no matter in the space between the earth and the other heavenly bodies, there must be something besides matter filling the space. This hypothetical substance was named the ether, and every later discovery has added evidence as to its existence, so that now we may consider the ether as a proven fact. And in late years the notion of the ether has assumed greater and greater importance. Sir William Thomson has advanced the theory that matter itself is but ether under various conditions of motion, and he, together with J. J. Thomson, has in some way proved it. If we can account for matter by modifications of the ether, then ether and energy, with the phenomena incident to them, may give us an entire mechanical explanation of the universe, and we can believe that, as far as this mechanical explanation is concerned, we need but ether and motion. And the importance of the ether to us to-night is this, that it seems more than probable that all electrical

* Abstract of a lecture delivered before the Franklin Institute.

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actions of whatever kind, and however made apparent, are transmitted through the ether and by it; and, indeed, the term electricity itself may very well be a misnomer, and electricity positive and negative may only be two phases of the ether.

This ether theory is an attractive one. To unify all the phenomena of nature and to refer them to the same cause has been the dream of philosophers for many years. But although the conception is simple enough, the details are to us very complex, partly, perhaps, because we are ourselves entangled in that very complicated modification of ether called matter, and cannot perceive things which in their essence are only too simple for us to grasp.

In order to appreciate the change which has taken place in electrical ideas, let us briefly examine the old notions of what constituted the charge of a condenser, and of how electrical energy was conveyed by a wire. In the first case it was held that when we charged a Leyden jar there was a certain definite amount of the fluid electricity upon it, positive electricity on one coating, negative upon the other. When the jar is discharged the two fluids rush together and neutralise one another with some little noise and heat. The thoughts of the experimenters were concentrated upon the charged bodies. If there were two of them they attracted or repelled one another; this was the important fact. It remained for Faraday to show that the space around a charged body had an important part to play in the phenomenon. Substituting sulphur for air between the coatings of a condenser he proved that the capacity was greatly changed. From that time more and more attention has been paid to the space around charged bodies and less to the bodies themselves, until we have begun to consider the latter as simply serving to make evident to us something which is taking place in the surrounding space. But we will talk further of this in the light of some experiments which I will try later.

Our views about an electric current have also been profoundly changed, but much more lately; indeed, the new ideas have not spread very widely even yet. The old idea was that the fluid electricity flowed through a wire very much as water flows through a pipe. But the new idea is that the energy does not flow through the wire at all. At every point along the wire enough energy passes into it to account for the amount of heating done, but the energy is transmitted by the ether outside the wire. If I am running this motor, then the energy used in running it does not pass through the wire at all, but passes from the dynamo at the electric lighting station to the motor through the ether. The wire acts as the core of a disturbance in the ether, making the transfer of energy possible, but not itself transferring it.

But it is in another field of electric transfer that we have learned most about the real actions which go on, and a great part of our knowledge is due to three men—Faraday, Maxwell, and Hertz. In Faraday's endeavours to unify the different phenomena of nature he was led to look for some connection between magnetism and light, and he found that there was such a connection, the plane polarisation of light being rotated in a magnetic field.

Maxwell, drawing his inspiration from Faraday, investigated the propagation of an electrical wave through space, and found that it followed the same laws as do light waves, and the velocity was the same as that of an electrical constant, which, on determination, proved to be that of light. So he advanced the hypothesis that light is really an electrical phenomenon. The proof of the hypothesis, however, rested on the fact that velocity of the electric disturbance was that of light, and that certain other electric constants bore the relation to optical constants that theory indicated. It remained for Hertz, a young German, scarcely thirty years old, to show by direct experiment that electrical waves are practically identical with those of light, and to put the electro-magnetic theory on a firm foundation. His method was to produce electrical waves of very short period, say $\frac{1}{100000000}$th of a second, and to directly investigate the method of their propagation. I have indicated on a large scale one way of experiment.

In the first place, if we have two tuning-forks of the same pitch and sound one of them, the other will sound sympathetically as it is called. Air waves are formed by the first fork, and these impinge on the second, causing motions, slight at first, but which are successively added, provided the forks are in tune, until the second fork sounds audibly. If the two are not in tune, the successive impulses are not added, but neutralise one another.

Now, is it possible to try a corresponding electrical experiment, and to do the same thing with electrical waves that we have done with air waves? In the first place, when I discharge this Leyden jar, the only thing we see is a flash of light. But if the energy of this charged jar is really stored up in the ether, then the ether is in a state of strain just as a stiff steel spring would be if it were fastened at one end and the other pulled aside. When we let go the spring, it will vibrate for a while, and in the same way when we let go the electrical strain by discharging the jar there will be an electrical vibration, and as the rate of vibration of the spring depends on its stiffness and weight, so the rate of electrical vibration of the jar depends on its capacity and the self-induction of the discharge circuit. That is, if the jar is smaller the time of vibration is less, and it is smaller for a short than for a great length of wire. So, by having a very small capacity and short wire, Hertz has obtained 2×10^8 vibrations in a second; a number comparable with the vibrations of light.

Suppose we have a circuit of wire with a break in it, and suppose I set up vibrations in the circuit; then I have another circuit which also has a break in it, and I can increase the capacity and therefore change the time constant of either circuit by putting these jars in the circuits. Now, if waves are really sent off from the first circuit, and if the two are in tune, then I may get indications in the second. If I put the two circuits out of tune, there will be no indication in the second. You see the results. This experiment shows us that waves of electric energy are transmitted through the space between the circuits, and it is very imperfectly Hertz's method of experiment. With circuits so small that they could be easily carried about, he investigated the direction of the waves and their length. He found that they were reflected like light waves; that they were refractive and, in fact, that they were practicaliy identical. He directly measured the velocity, too, and found it to be, as nearly as he could measure, the same as that of light. In fact, the evidence is all but conclusive that light is an electro-magnetic phenomenon, and we know that light is transmitted by the ether, so we have at least one form of electric energy, which is transmitted by the ether.

Now, let us take up another form of transmission; namely, along a wire. Here we must try to label the energy coming from the dynamo and follow it to this lamp or motor. Poynting and Heaviside first proved mathematically that the energy appearing in the wire in the form of heat rains down on the wire from the space around it, and the matter has an important practical bearing. Suppose I have a tube, open at both ends, immersed in a tank of water, and suppose the length of the tube is great compared with its diameter. I can represent with it the old and the new idea of electric currents. If there is a piston in the tube and if I push the piston through, the water which represents the current will move steadily along the tube; the velocity of each point in its section is the same, it will move as fast near the outside as in the middle. If we move the piston back and forth rapidly, we will have a current alternating in direction; but the distribution of velocity will still be uniform. Now, suppose we remove the piston and simply move the tube in the water. If we move it slowly and in one direction, the friction of the sides will carry the water along with it, the current being represented by the rate at which the water passes a fixed point, and the distribution is uniform. But if we move the tube rapidly back and forth through a short distance, the condition of the water in the tube will be different according as it is near the centre or near the outside of the tube. If the alternations are rapid and the amplitude is small, then the water near the centre may not move at all. In the first case, we have a current caused by a force acting along the wire; in the second, by a force all along the wire on the outside. The effect is the same for both in the case of a steady motion, corresponding to a steady current, and the distribution is uniform across the section, as it is in the case of a steady current through a wire. But in the case of the alternating forces the results are different; a force along the axis giving a uniform distribution, the force acting from along the outside giving a greater motion near the surface. Which of these corresponds with our experience in the case of alternating electric currents? The last does. With an alternating current along a wire, if the period be very small, a very little of the current reaches the centre.

Other experiments show the same thing almost conclusively, namely, that the energy of an electric current is conveyed by the ether around the wire. But if the wire does not convey the current, how does its presence affect the ether in its neighbourhood? With our present knowledge of the properties of the ether it is impossible to say. We may represent the state of things, if we wish, as Lodge has done. He imagines that the ether is made up of a number of cog-wheels meshing into one another, and he further imagines that a conductor consists of wheels which have no teeth, but whose rims can slip over the cogs with a certain amount of friction, and so with a certain production of heat. If we had nothing but the cogs, we could not make them rotate, for they would tend to turn each other in opposite directions and would stick fast. But with a number of wheels over which the cogged teeth could slide, rotation would be possible, and we would have a condition of affairs representing a current.

If the wheels were elastic, then, if we try to turn one of them, there being no conductors around, the wheel would turn slightly, and this partial turning would be transmitted to the next, and so on; there being a definite strain through the whole space due to the stretching of these rubber wheels. And Lodge would represent the charging of a Leyden jar by this—the distention of the wheels representing the strain in the ether. We must then consider the charge of a Leyden jar as represented by a partial rotation transmitted through space with a velocity dependent on the elasticity of

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the wheels and their mass. When we discharge the jar, the wheels are relieved from their strain and oscillate for a while about their position of rest. If we will consider for a moment, we will see that if there were such wheels half would revolve with, half against the hands of a watch, and this difference in the direction of rotation of the wheels may be taken as in some way representing the difference between positive and negative electricity.

And this model of the ether would in some way explain magnetism. The rotating cogged wheels represent magnetic effects, and if they rotate they must of necessity be included in a current. So we only have to adopt the old theory of Ampère, who supposed magnets were made up of a great number of small currents circulating around the molecules of the magnet, and our model fits in with the facts of magnetism also. But no one—least of all Prof. Lodge—believes that this actually represents the mechanism of the ether. It helps us to have some definite notions, and no one has been more helpful than Prof. Lodge. But whatever the exact nature of the actions, there is not any doubt that some motion of rotation in the ether accompanies electrical and magnetic actions, and that electrostatic actions are caused by a strain in the ether.

We have taken up in an imperfect way three types of electric action, or rather four. Electrical waves, electrical strains or static electricity, and electric currents, and in the latter we have included magnetic actions, especially if we accept Ampère's hypothesis. There is one thing we have not taken up, and that is the passage of an electric current through liquids. But this I will not take up.

So much for the transmission of electric energy; for its sources we can go in many directions. The largest, most important, and cheapest source of electrical energy is the sun. The energy which makes up the organic life on the earth, the energy which causes the growth of every flower and plant and animal comes to us as electrical energy. Through many transformations, after long waiting sometimes, the electrician takes it again; transforms it a second time into electrical energy, and then distributes it for the uses of mankind.

ELECTRIC LIGHTING PROVISIONAL ORDERS.

The following is a complete list of the Provisional Orders which have received Royal assent during the past Session of Parliament. Altogether there were 15 Bills, the last of which (relating to the City lighting) received assent on the 18th inst.:—

C. = Company. L.A. = Local Authority.

Aberdeen	L.A.	Leicester	L.A.
Accrington	L.A.	London, City of London	C.
Ashton-under-Lyne	C.	,, ,,	C.
Ayr	L.A.	Crystal Palace District	C.
Bacup	L.A.	Lambeth	C.
Barnsley	L.A.	London Electric Supply Co...	C.
Bedford	L.A.	Metropolitan Electric Supply Co.... (Includes Paddington.)	C.
Belfast	L.A.	North London	C.
Birkenhead	L.A.	St. James's and Pall Mall	C.
Blackburn	L.A.	Wandsworth	C.
Blackpool	L.A.	Malvern	L.A.
Bognor	C.	Manchester	L.A.
Bournemouth (Brush)	C.	Moss Side and Stretford	C.
Bournemouth (House-to-House)	C.	Morecombe	C.
Burnley	L.A.	Northampton	C.
Burton-on-Trent	L.A.	Nottingham	L.A.
Bury	L.A.	Oldham	L.A.
Cambridge	L.A.	Oxford	C.
Chatham	C.	Plymouth	C.
Cheltenham	L.A.	Portsmouth	L.A.
Chester	L.A.	Preston	C.
Coatbridge	C.	Preston and Fulwood	C.
Darlington	L.A.	Salford	L.A.
Derby	L.A.	Sevenoaks	C.
Dover	L.A.	Stafford	L.A.
Dundee	L.A.	Stockton-on-Tees	L.A.
Eastbourne	C.	Tiverton	L.A.
Fleetwood	L.A.	Tunstall	C.
Galway	C.	Walsall	L.A.
Glasgow	L.A.	Wigan	L.A.
Great Yarmouth	L.A.	Windsor	C.
Hastings and St. Leonard's	C.	Woking	C.
Hastings	L.A.	Wolverhampton	L.A.
Hove	L.A.	Worcester	L.A.
Huddersfield	L.A.	Wrexham	C.
Kelvinside	C.	York	L.A.
Kingston-on-Hull	L.A.		
Lancaster	L.A.		

Electric Lighting of Inverary Castle.—On Monday night the electric light was tested for the first time at the Castle, and proved to be very satisfactory.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *August* 15, 1890.

A PROPOSED TELEGRAPH LINE BY THE WHITE SEA.—A telegraph line, which is expected to prove of considerable use to the northernmost part of Europe, is at present under contemplation by the Russian Postal and Telegraph Department, viz., along the borders of the White Sea *viâ* Kala to the Norwegian frontier. It will, according to the present plan, be taken in hand next year, and will no doubt prove a great boon to the Murman Coast, where they now have a post only twice a week.

THE HOLMSTAD INSTALLATION.—This central station is about ready, and will soon begin its work. In addition to the public street lighting there are subscribers for about 500 incandescent lamps.

THE ELEKTRON COMPANY.—The new central station of this Company at Gothenburg has at present a capacity of 4,000 incandescent lamps, but is capable of an extension up to 10,000 lamps. The dynamos are of Crompton and Co.'s make, and the same firm has also supplied the accumulators intended for use during the night and in summer days, and the Company supplies light through the twenty-four hours without necessitating the continual running of machines. The steam engines are on the triple expansion system, with patent safety boilers for 150 lb. pressure, and are so economical with regard to fuel that the consumption of coal only amounts to $\frac{3}{4}$ kilo. per hour for ten 16-candle incandescent lamps. The whole station is built under the directions of the engineering firm of Calvert and Co. The Company does not only supply light, but also power to a number of smaller workshops, such as cabinet makers, venetian-blind makers, &c. Where only power up to ten horse-power is required this arrangement seems to answer very well, as the motor is much cheaper than a gas or a steam engine in first cost, the working is cheap, and the motor is anything but complicated. For the working of a number of sewing-machines in one place it gives great satisfaction.

COPENHAGEN RAILWAY STATION.—In Copenhagen the State Telegraphs have just contracted with Prof. C. P. Jürgensen's well-known establishment about a large installation at the Copenhagen Railway Station, which, however, does not comprise the passenger station. The installation comprises 30 arc lamps and 200 incandescent lamps.

TELEPHONING TO SHIPS AT ANCHOR.—Telegraphic communication has been introduced at the naval manœuvres in Sweden, now going on. On board every ship is a telephonic apparatus and the connecting wires, which are laid out very quickly and taken up along the anchor chains. In the same manner connection can always be obtained with the State Telegraphs, whereby, of course, the whole country can be communicated with. Altogether the telephone is used regularly on board ship in Sweden, where many of the trading steamers are brought into telephonic connection with the town telephone within half an hour of their arrival, an arrangement which has proved itself eminently useful and practical, and the introduction of which is on the *tapis* in various places.

ELECTRIC RAILWAY.—The first electric railway in Sweden is now ready, viz., at Borholm, in Östergötland. It has been built for the local traffic of the Borholm Iron Works, for the transport of raw material and the finished produce, which has hitherto been a very troublesome matter on account of the local conditions. The electric locomotive, which is of American make, works satisfactorily one or more trucks with loads of about five tons each. The electric power is supplied by two Wenham dynamos, which are worked by a 50 horse-power turbine.

CORRESPONDENCE.

ELECTRICAL NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At the regular monthly meeting of the American Institute of Electrical Engineers held on June 17th last, a proposal was submitted to advocate the connection of the names of Franklin and Henry with the names of some electrical units, and in particular to connect that of Henry with the unit of self-induction. I venture to think that this proposal deserves attention. The British Association Committee on Electrical Standards committed itself last year to the adoption of the term *quadrant* as a name for a practical unit of self-induction, and in face of the fact that private enterprise had already coined and set in circulation the name "secohm" for that of a practical unit of the same nature. Both these terms involve a

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departure from the principle first suggested by Mr. Latimer Clark and Sir Charles Bright in 1861, and adopted by the British Association Committee in 1862, of forming the names of practical units out of the surnames of distinguished investigators.

Objection has been taken to the term "quadrant" in that it conveys the notion of *a length*, and that it is not desirable that the name of a unit should convey the idea of its dimensions on a particular system of measurement, which now is, but tomorrow may be replaced by some other mode. I will not discuss the *pros* and *cons* of this point, but limit myself to the suggestion that the practical unit of self-induction in the system of measurement which employs the ampere, volt, and ohm, &c., as units, should be called a *hen*. Henry first actually observed the effect and invented the term "self-induction," and used it in a memoir published in the *American Journal of Science*, in July, 1832; whilst the account of Faraday's investigations on the extra current was not published until December, 1834. Henry has, therefore, every claim to be considered as the discoverer of the fact and the inventor of the name; and in employing this short monosyllable for the name of that practical unit, we shall do justice to his work, and bestow upon the unit a name which carries no suggestion of dimensions, and which is susceptible of being used in such compounds as *microhen* and *millihen*, convenient for subdivisions of the unit. There is nothing to prevent any one from speaking of true *hens*, or legal *hens*, or British Association *hens* if it is required to be very precise. Instruments for the measurement of self-induction would be appropriately called *henmeters*, and the act of measurement *henometry*. There is more difficulty in recognising the mode in which to embalm the name of Franklin; but I desire to point out that, if a place should be found for him in our Pantheon of units, there is yet another, namely Gilbert, who deserves not to be forgotten. With diffidence I offer some suggestions on a magnetic nomenclature which will give opportunity to use them both. We want two practical units: one of magnetic induction, and the other of magneto-motive force (M. M. F.).

It may be questioned whether our time-honoured phrase, "number of lines of magnetic force" (or of induction) is entirely satisfactory from a practical point of view. The machinery of tubes of induction, surface integrals, &c., is admirable for its purpose, but it is much more suited to the class-room than the workshop.

It is also equally open to question whether the conceptions of magnetic force and magnetic induction derived from ideal visits to imaginary and exquisitely narrow crevasses in magnetised iron, the explorer being furnished with tiny imaginary "free poles" for experimental purposes, are of a nature best suited to assist actual magnetic engineers. Let us suppose all this for the moment set on one side, and adopting ideas well expounded by Mr. Bosanquet in the *Phil. Mag.* for 1883, Vol. XV., p. 205, consider only magnetic induction as something produced in the iron by magneto-motive force, just as current is produced in a circuit by electro-motive force. Magneto-motive force is produced in a magnetic circuit by linking it with current-turns. Let us dismiss the term "magnetic resistance," objected to by some on the grounds that "resistance" involves ideas of dissipation of energy, and speak of the *magnetic pliability* of a magnetic circuit to indicate its capability of experiencing magnetic induction under impressed magneto-motive force.

Then, further, let it be granted that the total magnetic induction in a magnetic circuit is measured in *gilbs*, and that the gilb is the unit of magnetic induction, one gilb being equal to a hundred million C.-G.-S. units of induction, and being defined by the condition that a uniform rate of change of induction in a magnetic circuit of one gilb per second produces an electro-motive force of one volt in an electric circuit linked with it. Let magneto-motive force or difference of magnetic potential along a magnetic circuit be measured in *franks* and let one frank be defined by the condition that a uniform slope of magnetic potential along a magnetic circuit of one frank per centimetre of length produces magnetic induction of one gilb per centimetre of cross-section in that circuit, when that circuit consists of material of unit pliability (permeability).

What is now called "the induction" (B) will be called density of or intensity of induction," and be expressed by gilbs per square centimetre.

The magneto-motive force will be expressed in franks or microfranks, instead of $\frac{4\pi}{10}$ times the ampere-turns (one microfrank = 80 ampere-turns); and the general relation between the magnetic quantities will be that the density of the magnetic induction in a closed magnetic circuit uniformly acted upon by M. M. F. is proportional to the magneto-motive force per unit of length, and to the magnetic pliability of the material of that circuit.

Magnetic pliability is a constant quantity (taken as unity in measurement) for all non-magnetic circuits; but in ferro-magnetic circuits it is a function of the induction or of the magneto-motive force. Tables can be made out from the observations on permeability at various inductions, giving the pliability of different kinds of iron for magneto-motive forces of different magnitudes applied in particular ways.

Suppose, for example, that a ring is wrapped over with insulated wire, and that there are 100 turns of wire on it, and that a current of 8 amperes is sent through it; there are 800 ampere-turns, or 10 microfranks of magneto-motive force impressed on that closed magnetic circuit uniformly. Let the length of that annular solenoid be 100 centimetres. The slope M.M.F. is $\frac{1}{10}$ microfrank per centimetre. Hence, if the ring is of wood or brass, for which magnetic pliability is unity, we have that the density of induction in the circuit is $\frac{1}{10}$ of a microgilb per square centimetre of cross section. If the ring is of soft iron, proper tables would tell us that the magnetic pliability of soft iron under an impressed magneto-motive force of $\frac{1}{10}$th microfrank per linear centimetre is 1,200 units, and hence that for such iron ring the density of induction is 120 microgilbs per square centimetre (12,000 C.-G.-S.).

If the iron ring has a cross-section of two square centimetres, and is wrapped over also with 10 turns of secondary wire, and the primary curent is completely reversed in $\frac{1}{100}$th of a second, the rate of change of total induction through this secondary would be approximately 480,000 microgilbs per second, and create in the secondary a mean electromotive force of nearly half a volt during the time the uniform rate of change of induction was proceeding.

These rough suggestions will perhaps show that from a practical point of view calculations for dynamo and transformer work might be simplified by the use of such units. The employment of a properly simplified nomenclature for the magnetic units will be a gain, and some such modifications as I have attempted to suggest are wanted for workshop use. One cannot readily teach workmen to handle formulæ bespattered with 4π and 10^8, μ and B; but the conception of ampere turns (80 of which constitute a unit) wrapped round an iron magnetic circuit, whether dynamo magnet or transformer core, acting to produce a certain density of something called induction (measured in gilbs), more or less according to the magnetic pliability of the material, grafts on to existing experience with electric currents, electric pressure, and electric resistance, and only wants a proper set of units and names to make it adapted for every day use. Perhaps some of your readers will give you their views on these matters.—I am, &c., J. A. Fleming.

NOTES ON A CURIOUS LIGHTNING FLASH.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Knowing that at the present time everybody's attention is turned towards thunderstorms, I send herewith what may be interesting to some of your readers.

On the afternoon of July 17th a storm broke over Surbiton of rather a severer character than has been known for some time past in this neighbourhood. The storm commenced between five and six o'clock, after a very sultry day, accompanied with a great darkness and much rain, the rain falling in dense sheets. At 6:40 I was fortunate enough to see one of those most appalling sights known commonly as globular lightning. The room I was standing in was situated about 30ft. from the ground, when all at once at the time mentioned

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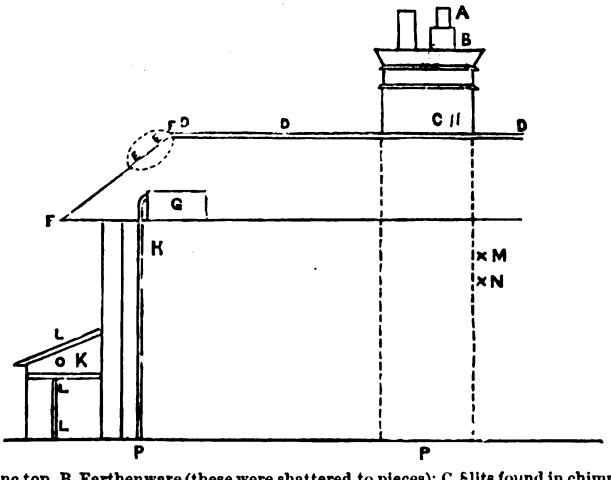
it seemed to me as if a huge ball of reddish yellow fire was suspended in mid air, about the level of the window. (The colour was that of an electric arc as seen in a dense fog). It did not last a moment, then it rapidly changed colour, and turned to an intense whiteness, more vivid than any other light I have seen, and burst with a terrific explosion, increasing in size many times over, and dozens of small splashes darted out of it on all sides; its brilliancy dazed me for several moments after. I have made several inquiries as to whether anybody else saw it; several people heard the explosion, but only a small boy saw anything of the real thing besides myself.



A, Zinc top, B, Earthenware (these were shattered to pieces); C, Slits found in chimney; D, D, Lead edging; E, E, Portion of roof quite smashed up; F, F, Slate; G, Cold-water cistern; H, Water-pipe, indications of fusing between H and wall; K, Verandah of wood and glass; L, L, L, Iron ridging, gutter and pipe; M, Mantel-piece, broken; N, Iron register, broken and thrown into room; P, P, Supposed earthing.

He states that he saw a big red ball moving along towards the house; but it soon passed out of his sight, owing to his situation in the room; but he heard a terrific bang just after it passed from his view. As far as I am able to discover, it came and went leaving no trace at all of its existence. Another fireball that was also seen in the neighbourhood was said by those who saw it to have been like a red ball surrounded by several smaller ones. I also heard of another one, but up to the present moment I have had no satisfactory details of either of these last two. Below will be found the account of two houses struck simultaneously within a few hundred yards of this house. By the kind courtesy of Mr. Dunlop and Mr. Tiffin, I have been able to make a careful examination of the result of this said flash; and I enclose a rough sketch, which will explain itself. It appeared to have struck the chimney stack, which is common to both houses, and descended inside for a few feet. Here it evidently separated into two branches: one branch continued down the chimney to a fireplace of the first-floor bed-room; here it broke the masonry around the fireplace, also breaking the register and throwing the same into the room in fragments. After this we have no further clue of this branch, except that a large quantity of soot was found on the kitchen range, so I presume that it burst into the kitchen flue, and earthed itself through the pipes under the range, &c.

Now, going back to B, another portion of the current burst through the chimney, leaving two small slits in the same to reach the lead edging, by which it continued its path to E, where the lead stops, and a slate edging commences. A little way down under this slate-edging there is a water tank, and over the tank is a pipe from the hot-water cistern. The lightning leaving the lead, which it fused at the end, made for this water pipe, fracturing a hole some 2ft. 6in. by 1ft. 6in. in the roof, splintering slates and rafters. The slate-edging here is very thick, being about the size of an ordinary man's wrist. A piece of the slate was driven right through the ceiling below, and another was driven with such force as to enter about 1in. into a beam. The hot-water system has been blocked since the house was struck.

We now come to what seems to me to be the most curious of everything; it will be seen by reference to the sketch that a verandah adjoins the house, partially formed of wood and partially of iron; at the spot indicated a round hole of about 2in. diameter has been pierced, as if a stone had been thrown from underneath, as I found glass outside the hole on top; it seemed as if the glass had been fused round the edges, but not to the extent one would expect. A very small quantity of glass was found inside. There was no further indication of the lightning going to earth to be found. I have been looking through some periodicals, and I came across one of Dr. Oliver Lodge's Papers read before the Institute of Electrical Engineers, in which he quotes "Note on the Lightning Flash at Antwerp Railway Station," by M. Melsens. It seems to me, on reading this, that this case bears a little resemblance, although the fusing of the glass in this instance is very slight. The fusing of the glass is on the inside of the glass.

If it was not for the fusing of the glass, which is very slight (which glass is still preserved), I would naturally think that this hole was caused by a piece of slate in falling, &c. I would also here note that the verandah door was wide open. That the house next door, which is only a few yards off, and certainly higher, is thoroughly well protected by lightning conductors. Also that except for the fusing between the different pipes on descending the house, and also of the lead, there is no indication of scorching or charring.—Yours, &c.,

Surbiton, July 22, 1890. D. F. Adamson.

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TRADE NOTES AND NOTICES.

TENDERS WANTED.—Tenders are required for lighting the parish of Heavitree with gas, electricity, or otherwise, for three years from October 24. Particulars may be obtained from Mr. Geo. Havill, jun., Fore-street, Heavitree, to whom tenders are to be sent by the 30th inst.

——— The Kinsale Town Commissioners also require tenders for lighting the town for twelve months. Tenders are to be sent by September 1 to Mr. J. F. Hegarty, acting clerk, Town Commissioners' Office, Kinsale.

WOODHOUSE AND RAWSON UNITED (LIMITED).—This firm have been awarded a silver medal for their show at the Exhibition of Fire and Life-Saving Apparatus now being held at Amsterdam.

THE LIGHTING OF SMYRNA.—In his last report to the Foreign Office, Her Majesty's Consul-General states that the electric light is installed in several private establishments at Smyrna, and proposals have been discussed for adopting it in the place of gas, by which the streets are now illuminated. This change, the Consul thinks, is likely to be carried out in the near future; the Gas Company, which is a British corporation, being quite prepared to change their plant as soon as the Municipality offer them a reasonable and durable contract.

DISC-CUTTING TOOL.—The Martignoni disc-cutting tool was shown in operation at the show-rooms of the Machinery and Hardware Co., Queen Victoria-street, yesterday. This tool is another addition to the numerous inventions for saving forging, careful grinding and the waste of material due to short ends, &c. The tool consists of a disc, whose edge is formed to the necessary shape, and part of it is notched away to give a cutting edge. Grinding must be done by a thin or special emery wheel, grinding always to a radius. The system appears to be considerably more expensive than that of Messrs. Smith and Coventry, and will, probably, notwithstanding its merits, meet with a similar opposition. The idea seems to be specially useful in the case of screw chasers. The tool is then merely a slice of a single fluted tap. These tools can be removed from the holder, sharpened, and reset with the certainty of perfect accuracy. If they can be supplied at a reasonable price, and if turners can be induced to use them, they should, in many cases, prove to be very useful.

COMPANIES' MEETINGS.

General Electric Company (Limited).

The statutory general meeting of the shareholders of the General Electric Company (Limited) took place on Tuesday, at the offices, 71, Queen Victoria-street.

Mr. GUSTAV BINSWANGER (the Chairman of the Company), who presided, stated that the business of the Company was divided into three departments—electric lighting, electric bells, and the works at Manchester. The result of the trading was that they were able to recommend a dividend of 15 per cent. on the Preference shares, and of 7½ per cent. on the Ordinary shares, carrying, at the same time, a sum of £637 to reserve. This result must be considered extremely satisfactory, inasmuch as the earning power of the Company upon the actual capital invested was more than 25 per cent. per annum. The business was continuing to show a very substantial increase, and as the winter was the best time for a business of this description, they had every prospect of being able to double the returns. The Chairman concluded by moving the adoption of the report and accounts.

Mr. MYERSTEIN seconded the resolution, which was unanimously agreed to, and the dividends as recommended were also declared.

Mr. T. J. Seel was re-elected auditor of the Company.

The proceedings then terminated.

NEW COMPANIES REGISTERED.

ATLAS ENGINE COMPANY (LIMITED).—Registered with a capital of £12,000 in £1 shares. Objects: To acquire the Atlas Engine Company, at Poole, Dorset, and to carry on the business of engineers, electricians, electric light contractors, dynamo manufacturers, &c.

GORDON ELECTRIC TRACTION SYNDICATE (LIMITED).—This syndicate was registered on the 13th inst., with a capital of £2,400, in £10 shares, to purchase the invention of John Gordon, of a system of electric street car traction, the provisional protection for which is dated 5th May, 1890, No. 6,083.

NONPAREIL ELECTRIC SYNDICATE (LIMITED).—This syndicate was registered on the 13th inst., with a capital of £6,000, in £10 shares, to acquire the letters patent No. 1,757, of 1889, for a new and improved coin freed machine for giving electric shocks, granted to Joseph Mason.

TRUJILLO RAILWAY (PERU), LIMITED.—Registered by Smiles and Co., 15, Bedford-row, W.C., with a capital of £500,000, in £1 shares. Object: To acquire, construct, repair, complete, equip, maintain, and work railways, tramways, telegraph and telephone lines and other means of communication for appliances of a similar nature in Peru, and for such purposes to acquire all or any of the rights of the Peruvian Corporation, under any concessions or contracts relating to any such means of communication or appliances; to carry into effect an agreement, made August 13th, between the Peruvian Corporation of the first part, Thomas Edwin Webb, as trustee on behalf of a company to be incorporated under the name of the Trujillo Railway of the second part, and Michael Paul Grace of the third part.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 15th amounted to £4,838.

HALIFAX AND BERMUDAS CABLES.—In the House of Commons, on Thursday last week, on the vote of £28,375 for subsidies to telegraph companies, Dr. Cameron moved the reduction of the vote in respect of the proposed subsidy to the Halifax and Bermudas Cable Company in connection with the cable recently laid by them. In the course of a long speech Dr. Cameron complained that the House had not been informed of the actual contract under which it was proposed to pay this subsidy. He took exception to the prospectus of the Company, and further complained that although the nominal capital amounted to £50,000 he had found, after inquiry, that only £35 was held by the seven subscribers to the Company. He thought that if the Company came to grief the Debenture holders would have the right to tell the Ministry that a public warning against the prospectus should have been set out. Mr. Jackson, the Financial Secretary to the Treasury, said, in reply, that he had already given a full explanation of the facts of the case, and that he must decline, on the part of the Government, to accept any responsibility for statements made in the prospectus. The Government had taken a new departure with the object of securing the laying of the cable. The proper security was provided, the capital was subscribed, and the cable was in good working order. He thought the Treasury were to be congratulated on the economical manner in which they had carried out the undertaking. The House seemed satisfied with the explanation, and the reduction of the vote was negatived by a majority of 36.

STOCK EXCHANGE.—Application has been made to the Committee to allow the National Telephone Company (Limited), 2,284 addional shares Nos. 436, 701 to 438, 984, to be quoted in the "Official List."

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended August 15th show an increase of £162 as compared with the corresponding period.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 15, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,718.

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WAREHOUSE.

VULCANISED FIBRE,

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The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

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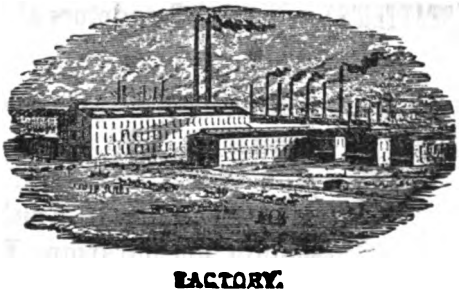
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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 13.		Price Wednesday, Aug. 20.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Aug. 20.	
										Highest.	Lowest.
£			**TELEGRAPHS.**					£ s. d.			
1,381,390	Stock	15/0	Anglo-American	49⅛	50⅛	50⅛	51⅛	5 8 6	Jan., Apr., July, Oct.	51	49⅝
2,809,310	Stock	30/0	Do. Preferred	85	86	87	88	6 7 6	,, ,,	88	85½
2,809,310	Stock	..	Do. Deferred	13⅝	14½	14⅞	15½	..		15½	13⅞
250,000	£100	4%	African Direct, 4 per Cent. Debentures	97	100	97	100	4 0 0	January and July	..	..
130,000	10	3/0	Brazilian Submarine	11⅜	12⅛	11⅜	12⅛	5 6 1	Mar., June, Oct., Dec.	12 1/16	..
69,200	100	5%	Do. 5 per Cent. Bonds	100	102	100	102	4 18 0	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	..	..
..	$100	..	Commercial Cables	103	105	103	105	..	..	105	103½
16,000	£10	9/0	Cuba Submarine xd	12⅝	13½	12¼	13	6 15 10	February and August	..	..
6,000	10	10%	Do. Preference 10% xd	17	18	16¾	17½	5 11 1	,, ,,	..	..
12,931	5	5½% 1889	Direct Spanish (£4 paid)	3½	4	3¼	4	5 10 0	March & September	3 13/16	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 15 0	Jan., Apr., July, Oct.	10½	10½
400,000	10	5/6	Eastern	13⅝	14⅛	13⅝	14⅛	4 12 0	,, ,,	14⅛	13¾
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	,, ,,	15	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	109	106	10)	3 13 5	May and November	108	107
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	107⅞	..
250,000	10	2/6	Eastern Extension	14	14½	14	14½	4 18 3	Jan., Apr., July, Oct.	14 5/16	14 1/16
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	100⅛	..
91,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	100	103	100	103	4 17 1	,, ,,	102	..
180,227	10	4/3	Globe Telegraph and Trust	8⅞	9⅛	8⅞	9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
150,042	10	6%	Do. 6 per Cent. Preference	14⅞	15⅛	14⅞	15⅛	3 19 4	,, ,,	14⅞	14⅝
150,000	10	5/0	Great Northern	15½	16	15½	16	4 13 9	Jan., April, and July	15 1/16	15⅛
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100	103	100	103	4 17 1	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	106	
17,000	25	37/6	Indo-European	37	39	37	39	6 7 2	April and October	38⅜	38⅛
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	109	..
9,000	8	6/0	Reuter's	7⅜	8⅛	7⅜	8⅛	6 1 3	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	113	117	113	117	5 2 7	,, ,,	..	..
15,609	£10	6/6	West African	9	10	9	10	5 0 0	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	100	103	10)	103	4 17 1	March & September	..	..
30,000	10	3/0	West Coast of America	5	6	3	5	..	January and July	4½	3½
150,000	100	8%	Do. Debentures 8%	106	110	106	110	7 5 6	June and December	106	..
88,321	10	Nil.	West India and Panama	2⅜	3	2⅜	3	..	..	2⅜	2 1/16
34,563	10	6/0	Do. 1st Preference 6%	11½	11⅝	11½	11⅝	5 2 2	April and October	11⅝	11 1/16
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	13	14	13	14	4 5 9	..	..	..
64,572	15	6/0	Western and Brazilian	10⅜	11½	11	11½	5 6 6	May and November	11½	11½
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6½	7	..	..	6 13/16	6½
26,986	7½	4/6	Do. 5 per Cent. Deferred	4	4½	5	5½	..	..	4¼	4⅛
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103	106	103	106	5 13 2	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101	104	101	104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5½	Consolidated Telephone Const. and Maintenance	1/16	1/8	1/16	1/8	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼	⅜	¼	⅜	4 8 8	Yearly	..	..
436,700	5	3/0	National	4⅛	5⅛	4⅛	5⅛	5 17 1	June and December	5 1/16	5
15,000	20	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12⅛	12⅜	12	12⅛	4 14 1	June and December	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10	10⅛	10	10⅛	4 11 9	,, ,,	..	..
209,750	1	¼%	South of England, Ordinary	⅛	⅜	⅛	⅜	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd).	2⅛	3	2⅛	3	6 19 11	..	..	..
55,000	5	1/0	United River Plate	3⅛	4⅛	3⅛	4⅛	..	January and July	4⅛	3⅛
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	1⅞	2	1⅞	2⅛	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4	4⅛	4	4⅛	..	..	4⅛	4⅛
42,853	5	..	Westminster Electric Supply	1⅛	1⅜	1⅛	1⅜	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1⅞	2	1⅞	2	..	..	..	..
63,416	2	1/2	Do. Preference	1⅞	2	1⅞	2	..	..	..	..
20,000	5	7½	Crompton and Co., 7 per Cent. Pref. Shares	5½	5⅞	5½	5⅞	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..		7⅞	8⅛	..	..	..	..
419,000	10	..	Electric Construction	7⅞	8⅛	..		..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5⅞	6	6	6⅛	..	..	6⅛	5⅞
20,000	5	..	Fowler-Waring Cables	2	2⅛	2	2⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½	19½	18½	19½	5 2 7	February & August	18 5/16	18½
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5	5⅛	5	5⅛	3 16 5	..	5⅛	..
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43½	42½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100	102	100	102	4 18 0	..	..	..

JABLOCHKOFF'S **DISTRIBUTION PATENT**

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 641.—Vol. XXV. FRIDAY, AUGUST 29, 1890. Price Fourpence.

NOTES.

In addition to the Papers the titles of which were given in our last issue, we learn that the following communications will be made to Section A at the forthcoming meeting of the British Association:—"On the Permanence of some Standard Resistance Coils;" "On Two Air Condensers recently constructed for the Electrical Standards Committee;" "On the Specific Resistance of Copper;" "A Comparison of a Platinum Resistance Thermometer and some Kew Standards;" "On Recent Determinations of the Absolute Resistance of Mercury;" "A Report on Recent Progress in our Knowledge of Electrolysis." The work of the Electrical Standards Committee is in very able hands, and is the result of a great deal of research of a high order, probably no feature of the British Association being of so great importance to the electrical engineer. The purely Electrical Engineering Papers are seldom of any great importance compared with those which are read before the Institutions in London, nor do they interest the majority of the frequenters of Section A, while Section G is not, as a rule, remarkable for the novelty of its Papers on either Electrical or Mechanical subjects. Sir William Thomson will contribute to Section A Papers "On Alternate Currents in Parallel Conductors of Homogeneous or Heterogeneous Substance;" "On Anti-Effective Copper in Parallel Conductors or in Coiled Conductors of Alternate Currents;" "On an Illustration of Contact Electricity presented by the Multicellular Electro-static Voltmeter;" and to Section G, "On a New Electric Meter."

A concise statement of the electro-magnetic theory of light has been long wanted. The exposition given in Maxwell's treatise leaves much to be desired, since the essential parts are scattered in various portions of a work dealing with many other subjects. Maxwell's book is very unequal in different parts; for, while aiming at giving a mathematical interpretation of Faraday's views on electricity, a considerable amount of analytical and descriptive matter is introduced which, although of great value, is needless for the main object in hand. Moreover, at the time the book was written there was but little experimental evidence in favour of the electro-magnetic theory, and it was therefore wise to keep it somewhat in the background. Now, however, that the theory has been confirmed by many researches, it is time to state it in a concise manner suitable to an accepted theory.

This task has been undertaken by Prof. Hertz, an abstract of whose work will be found in our present issue. It is highly satisfactory that one who has contributed so much to the experimental verification of the principles involved in Maxwell's theory should be also able to improve upon the mathematical language used by its author. One advantage following from this combination is shown in many of the changes introduced; for, according to Prof. Hertz, and no one is better qualified to judge, some of the artifices used by Maxwell to facilitate mathematical working render the resulting equations less directly applicable to practice than would otherwise be the case.

Prof. Hertz is not the first to show the more perfect form in which Maxwell's theory can be stated; for our readers will remember that in 1885 Mr. Oliver Heaviside, in a long series of articles on "Electro-magnetic Induction and its Propogation," discussed the whole subject with very great ability; and, indeed, the greater number of Hertz expressions are to be found in almost the same form in Mr. Heaviside's work. The priority of the English mathematician is, however, fully acknowledged by the German professor, whose work is none the less welcome and valuable. It forms the most compact exposition of the theory which has yet appeared; while the absence of the quaternion expressions, so frequently used by Mr. Heaviside in analysis, will render it possible for a larger number of readers to follow the reasoning.

The letter of Major Flood-Page in *The Times* on "Fire Offices and Electric Light," of which we gave a brief abstract last week, has given rise to a correspondence in which Mr. Verity, Prof. Silvanus Thompson, and Mr. Campbell Swinton have taken part. Mr. Verity points out that the matter concerns others than the Fire Offices. The supply companies must be satisfied, and the contractor, "who could do his work more speedily and at a lower rate if uniform requirements were insisted on" and it "greatly concerns the house occupier who wants to be left in peace." He says that "it is an open secret that the great difficulties experienced in drawing up the *minimum* tests of efficiency have so long delayed the anxiously-expected Board of Trade regulations." We fear that Mr. Verity and others will be somewhat disappointed to find that these regulations, which we publish in another column, deal very briefly with the details of internal wiring. Rules 18 to 23 are practically the only ones, and Rule 22 dismisses

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the actual question of "fire risk" in two lines. Mr. VERITY urges that the Institution of Electrical Engineers is "the best and proper body" to grapple with the question; but Mr. CAMPBELL SWINTON points out that the Institution rules were drawn up "by a number of electrical scientists who, though of the highest eminence in their respective spheres, had, and can have had, but little or no experience of the practical difficulties that crop up in actual work," and suggests that they should appoint a Committee of "men who have actual practical experience in wiring houses, and in supplying current from central stations, and not mere theoretical knowledge, however eminent." Prof. SILVANUS THOMPSON joins with Mr. VERITY in acknowledging the indebtedness of the electrical industry to Mr. MUSGRAVE HEAPHY for the high standard of work which he has undoubtedly been the means of bringing about; but thinks that the rules of the Institution "owed their origin to an absurd outside jealousy directed against the Phœnix Fire Office; and asks "Why can we not all agree to accept them?" The answer is, we think, summed up by Mr. VERITY—"They leave too much to the discretion of the Surveyor."

IN connection with the list of Provisional Orders granted by the Board of Trade this year, and which we published in our last issue, it may be interesting to compare the actual results of the memorable electric lighting boom of 1889 with its promise. By the middle of last year no less than 474 notices of intention to apply for Provisional Orders had been served upon the various Local Authorities of the United Kingdom by some 60 electric light companies. This rush of notices, it will be remembered, created considerable alarm amongst the recipients of these "intimations of intention to apply," and a large number of Local Authorities immediately decided to obtain electric lighting powers themselves. However, by the end of 1889 only 161 applications, including those of the Local Authorities, were still being persevered with, and in the result only 74 Orders were granted. The ratio of the result to the intention was, therefore, in this instance about one to six.

LAST year the Board of Trade issued in all 11 Provisional Orders and two Licences, of which one Order and the two Licences related to Local Authorities. This year nearly 60 per cent. of the Orders have been granted to Local Authorities, to whom at least 60 Orders must have been issued since 1882. Up to the present, however, only one Municipal Order, that of Bradford, has been actually worked, although both Brighton and St. Pancras are at last fairly committed to large schemes. The number of Orders issued for metropolitan areas within the last two years is 17, all of which have been granted to companies, and the metropolis may, therefore, be considered as well equipped in this respect.

THE non-delivery of telegrams is always a fruitful subject of complaint whenever it is started in the newspapers, and the columns of *The Times* have been lately overflowing with it. Correspondents who adopt this means of airing their grievances are, if we may judge from their letters, sometimes unreasonable, often illogical, and occasionally contradictory: so much so, indeed, that we are half inclined to suspect that the people who have most to complain about do not trust their pens to describe it. For it may be safely conjectured that these outward signs of dissatisfaction, feeble as they are, are the sure indications of a real grievance that calls for remedy of some sort. Ever since the introduction of sixpenny telegrams, when every word in the addresses as well as the text has been charged for, a growing tendency has manifested itself on the part of the public to be unduly brief, and on the part of the Post Office to be unduly resentful of the consequent curtailment of the addresses. This is a result which indeed the Department itself has partly, if unwittingly, encouraged by sanctioning registered addresses, the public arguing that if a message can be delivered without any address to speak of when a fee is paid for registration, it can be delivered with equal certainty without such fee. Besides this, the habit of brevity in the message is bound to extend itself to the address, with consequent difficulty in delivery.

IT seems to us that it is idle to do battle with this habit by the drastic but fitful punishment of non-delivery. No doubt in a few instances non-delivery is not only excusable but unavoidable, as in the cases of several persons or streets of the same name; but in many others a little extra trouble would ensure the due delivery, and this trouble it would seem the Telegraph Department sometimes, though not always, declines to take; while, on the other hand, the Postal Department justly prides itself upon the wonderful skill with which illegibly written names are deciphered, and letters with absurdly inadequate addresses find their right destination. There is an element of uncertainty about the telegraph delivery, and the public, judging from *The Times* correspondents, are generally inclined to take the risk. Now, the true corrective of this state of things is for the Department to do all that reasonably may be done to deliver a telegram, but to take its time about it, and let the recipient know that the time has been needed. At this moment we have before us a letter which had gone astray through our correspondent addressing us incorrectly. It bears a stamp mark and some writing, which tells us plainly enough that a lot of time has been lost through the improper address; and we shall not fail to inform our careless correspondent of the fact. Why not adopt some such method for insufficiently addressed telegrams? If they were conspicuously stamped, "DELAYED IN DELIVERY THROUGH INSUFFICIENT ADDRESS," we fancy the warning would not often have to be repeated, and the Department would in every case tender its explanation on delivery. This would disarm complaint if reasonable pains were taken to deliver the message; whereas there seems no excuse for some of the cases of intentional non-delivery which have raised the indignation of the writers of these letters to *The Times*.

THE final arrangements have been made with the French Government for the new telephone cable, about which we gave definite particulars in our issue of the 1st inst. (page 342). We understand that Mr. PREECE went to Paris last week, and submitted the specifications and settled the necessary details.

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Tenders have been invited, and will be received to-day; and the order for the cable will probably be given early next week, other operations being pushed on at once. It may be expected that details of the recent experiments, and an account of the proposed line, will be given at the meeting of the British Association.

Electric Traction in Paris.—An electric tramway is now being laid down between the Trocadéro and the Place Rigalle.

Canterbury.—At a meeting of the Town Council last week it was decided that application be made to the Board of Trade for a Provisional Order.

The Electric Launches at Edinburgh.—It is stated that over 40,000 passengers at penny and twopenny fares have been carried in the electric launches at the Edinburgh Exhibition.

The "Elektrotechnische Rundschau."—On and after the 1st October next the *Elektrotechnische Rundschau* will be published by G. L. Daube, of Frankfort-on-the-Main, and will appear fortnightly.

Award to M. Carre.—The Gifford prize of 6,000 francs has been awarded to M. Ferdinand Carré, by the Société d'Encouragement, for his improvements in the manufacture of arc light carbons.

A New Alloy.—According to the *Bulletin International de l'Electricité*, MM. Bourbouze et Cie are manufacturing an alloy consisting of 100 parts of aluminium and 10 parts of tin, which is said to possess all the advantages of pure aluminium.

Telegraphic Communication with Tory Island.—The Duke and Duchess of Abercorn inaugurated last week the new signal and telegraph station on Tory Island. In future vessels will be reported from this station, instead of from Malin Head.

The Double Carbon Arc Lamp Patent.—In the action brought by the Brush Electric Company, of Cleveland, against the Western Electric Company, for infringement of the Brush double carbon arc lamp patent, a decision has been given sustaining the Brush patent.

The Meeting of the British Association.—In connection with the visit next week of the British Association to Leeds, a useful "Handbook for Leeds and Airedale" has been issued, under the editorship of Prof. L. C. Miall, of the Yorkshire College.

Personal.—We are informed that Mr. A. R. Bennett, who has been General Manager to the National Telephone Company for nearly eight years, has resigned that appointment, and will cease to administer the Company's affairs in Scotland at the end of October.

Lightning Fatalities.—During a storm at Loebschutz (Germany), on August 9th, some reapers sought refuge under some sheaves. The pile of sheaves was struck by lightning; some of the men were killed by the flash, and the others were burnt to death by the fire to which the flash gave rise.

Electric Railways in Karlsruhe.—A company has lately been formed for the purpose of building an electric railway between Beiertheim and Bulach. According to the *Elektrotechnischer Anziger*, it is also intended to build a line connecting Karlsruhe, Mühlburg, Neureuth, and Eggenstein.

Obituary.—We regret to announce the death of Mr. Julius Sax, which took place on Thursday last at his residence, 108, Great Russell-street, Bloomsbury. We are informed that arrangements have been made which will enable the business conducted by the late Mr. Sax to be carried on as usual.

A New Wire for Telegraph Purposes.—The French Postal Telegraph authorities have recently adopted a new type of telegraph wire, called the Martin bimetallic wire. It consists of a steel core, which is coated with copper, and it is proposed to use this wire both for telegraphic and telephonic purposes.

Cable Extensions.—The German Government has negotiated with the Eastern Telegraph Company for the laying of a cable between Dar-es-Salaam, Bagamoyo, and Zanzibar. The ss. "Amber" recently left London with the cable on board, and it is expected that the cable will be laid and working in September.

Telephone Monopoly in the German Empire.—In our Note last week of the result of the action brought by Messrs. Mix and Genest, of Berlin, against the German Government claims for a monopoly of the telephone, we should have stated that the decision given on July 10th was entirely in favour of Messrs. Mix and Genest.

The Life of Glow Lamps.—A correspondent writes from the United States:—"I have fifteen 32 candle-power 120 volt lamps that have burnt 7,591 hours, and are still intact. They are on an outside circuit, each and every lamp having received full pressure of 120 volts right along." A letter describing another phenomenal record will be found in our correspondence columns.

New Alternating-Current Motor.—According to the *Zeitschrift für Elektrotechnik*, the Allgemeine Elektricitäts Gesellschaft, of Berlin, has patented a new alternating-current motor, depending upon the repulsion that exists between two bobbins placed opposite to one another when they are traversed by an alternating current. This motor, like Tesla's, requires three conductors.

An All-Copper Rail Bond.—In electric railways, the resistance of the rail return depends largely on the connection between adjoining rails. The various forms of rail-bonds at present in use are made wholly or in part of iron, and leave much to be desired in the matter of conductivity. To fill this want, rail-bonds entirely of copper are being extensively manufactured in the United States.

The Chicago Electric Fountain.—The new electric fountain presented by Mr. C. T. Yerkes to the Lincoln Park Commissioners of Chicago is now completed. The fountain contains over 200 large jets, all of which are in play together and throw varying streams to the height of 75ft. In addition to these there are numerous smaller jets. The fountain has cost $50,000. Very satisfactory tests have been made.

Electricity and Soapmaking.—According to *La Lumière Electrique*, soap makers are trying the electrolysis of sea-salt solutions, with a view of obtaining caustic soda, from which to prepare the soda so largely used in the manufacture of soap. It is not necessary to push the electrolysis until the salt is entirely decomposed; in fact, at soap works soda lyes are used containing from 30 to 40 per cent. of their weight of salt.

Brussels.—Up to the 1st inst. four tenders had been received by the Brussels Municipality for the electric light scheme which it is proposed to carry out in that city. The first is a combined tender by Siemens and Halske, the Allgemeine Elektricitäts Gesellschaft, of Berlin, and the Compagnie de l'Électricité de Liège; the second is by M. Patin, of Paris; the third by Ganz and Co., of Buda-pest; and the fourth by the Société l'Électrique of Brussels.

Electric Lift at Salzburg.—An electric lift has been provided for raising passengers to the plateau of the Mönschberg, a height of 250ft. A battery of 126 cells by the Oerlikon Company supplies current to a Siemens and Halske motor, which winds the cable. The accumulators are charged during the day time by the dynamos at the Salzburg electric lighting station, a special cable having been laid for the purpose. The lift will hold 12 persons and weighs 25cwt.

Bath.—At the last meeting of the Sanitary Committee of the Town Council the inspector of nuisances reported with reference to the smoke nuisance at the electric light works. The Chairman said the black smoke pouring out of the chimney was something fearful, and other members spoke of the seriousness of the nuisance. It was intimated that Mr. Massingham was seeking a reliable smoke-consuming apparatus. Some 20 members of the Gloucestershire Engineering Society recently visited Bath for the purpose of inspecting the electric light works.

The Utilisation of Water-power in the United States.—The Missouri Power Company are building a gigantic dam across the Missouri River near Helena, Montana, for the purpose of utilising the power of the water. The dam is a timber crib structure, 800ft. long and 47ft. high, and the reservoir obtained by its means will cover an area of 429 square miles. The water will be led along a tunnel to the turbines, which will, it is expected, generate 20,000 h.p., and the power thus developed will be transmitted electrically to the mills, &c., at Helena.

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New Electrical Companies in the United States.—Since January 1, 1890, says the *Electrical Review* of New York, we have chronicled the formation of 482 new companies, which have been incorporated to do business in the electrical field in this country. This list includes the following branches of the industry: Electric lighting, electric power, electric traction, telephony, telegraphy, and the many sub-divisions of the electrical supply business. The average capitalisation of 100 companies, selected from the list at random, is over $150,000. Multiplying this by 482, we get $72,300,000 of capital authorised for investment in the electrical industry in a little over seven months.

The Telephone in Belgium.—The Belgian Bell Telephone Company has just issued its report for the year 1889. This Company works exchanges in Brussels, Antwerp, Charleroi, Ghent, Verviers and elsewhere. During 1889 the numbers of its subscribers increased by 8·5 per cent., and its net receipts amounted to 400,000fr., on a capital of 3,400,000fr., and after transferring nearly 300,000fr. to the reserve fund, it was able to pay a dividend of 7 per cent. on its paid-up capital. At the end of the year 1892 the Belgian Government will be able to acquire the concern according to the terms of the concession, the purchase price being based upon the average net income of the last three years, *plus* 15 per cent.

St. Thomas Charterhouse Schools.—The results of the late South Kensington examinations show that the pupils of this school have again achieved some praiseworthy successes. Out of 61 who were sent up for examination only three completely failed, while several were successful in the four subjects—Mathematics, Magnetism and Electricity, Sound, Light and Heat, and Solid Geometry, one boy obtaining four first classes. In Mathematics 17 obtained a first class, and very few were ploughed. The results in Magnetism and Electricity were exceptionally brilliant, 25 being placed in the first class and 26 in the second. At the City Guilds Technical College late Matriculation Examination all the pupils from this school were successful.

Severe Thunderstorms.—The South of London was visited by a severe thunderstorm on Sunday afternoon last. At the height of the storm the church of St. George's, Wells-street, Camberwell, was struck by lightning. Large pieces of cement were detached from the coping, and in some cases were carried 60 or 80 yards. Severe storms also took place on Tuesday last at Riston-in-Holderness; a farmer was killed by lightning. He had set off to ride to one of his fields, and was shortly afterwards found lying dead on the road, with his horse standing beside him. He was burnt about the head and face. A house at Burslem was struck, and the tiles were hurled from the roof, the gaspiping was melted, and the house set on fire by the ignited gas.

Bremen.—The electric tramway which came into operation at Bremen some two months ago is the first to be carried out in Europe on the Thomson-Houston overhead system. The line, which is one mile long, commences at the Town Hall in the centre of the town, and terminates just within the entrance to the town park. The generating station is situated near the park, and contains a Kirchen engine of 150 indicated h.p., and a dynamo of 84 electrical h.p., having a pressure at the terminals of 500 volts. The copper conductors are carried on insulators fastened to short pieces of steel cable attached to iron masts 20ft. high. There are now in regular service from five to six cars, each of which has two motors fixed in a special frame under the car body. The tramway is, with the exception of one narrow street, double throughout.

The Resistance of Ferro-Manganese-Copper Alloys.—A recent number of the *American Journal of Science* contains an interesting Paper by Edward L. Nichols, on the "Electrical Resistance of the Alloys of Ferro-Manganese and Copper" (from determinations made by Mr. B. H. Blood). The observations show that ferro-manganese-copper alloys decrease in electrical resistance each time they are subjected to a change of temperature. In one case an alloy containing 80·82 per cent. of copper and 19·12 per cent. of ferro-manganese was hard drawn in the process of obtaining a strip suitable for measurement. Its specific resistance at 20deg., referred to pure copper as unity, was 30·38; this resistance gradually diminished as the strip was repeatedly heated to 100deg. and cooled to 20deg., until after seven such heatings it had fallen to 30·072.

The West Metropolitan Tramways Company and Electric Traction.—At the general meeting of this Company held last week, the Chairman said that negotiations had been in progress in respect to electrical traction for several months; but eventually, he regretted to say, the electrical company withdrew their proposal. It was satisfactory, however, that fresh negotiations were in progress with another electrical company, who had expressed their willingness to undertake the work on advantageous terms as soon as the local authorities should have given their sanction. The relations existing between the vestries and the company were of the most friendly and amicable character, and, under all circumstances, he looked forward to being able, when the matter of electricity was settled, to give the shareholders a good return upon the money they had invested in the Company.

Chester.—At the last monthly meeting of the Town Council the Watch Committee recommended that the electric lighting Provisional Order should be referred to the Committee to report upon. Alderman Frost remarked that he thought it would be well to inquire as to the towns where electric lighting was in existence, and if it paid. If it was a source of loss it would not, he said, be a wise thing for the ratepayers to have to make up an annual loss. Alderman Gilbert pointed out that the step they were taking that day was merely to instruct the Watch Committee to glean information. Mr. Farish said that this matter was tentative from the beginning, and the Watch Committee had no intention, so far as he could gather, of hurrying the Council into any hasty steps. They had a gas company; and he thought they were fairly well supplied with gas. The recommendation was then agreed to.

Lightning on a Transmission of Power Circuit.—At a recent meeting of the Société de Physique, M. Hillairet gave an account of the damage caused by lightning to a transmission of power circuit five kilometres long, situated at Domène (Isère). As thunderstorms were known to be of frequent occurrence in this neighbourhood, the line was provided at either end with comb protectors, and care was taken to well insulate the framework of the dynamos from earth, the insulation resistance being about 100,000 ohms. On May 23rd the line was struck, and 19 out of 130 posts were split, showers of sparks were visible at the brushes of the machines, and the protectors, although uninjured, showed traces of violent discharges. The posts which were struck were altogether in one locality, and M. Hillairet attributes this fact to the presence of a sheet of water a short distance under the soil.

The New York Subway Litigation.—The first decision in the suit of the North American Underground and Electric Company against the Consolidated Telegraph and Electrical Subway Company, to which we referred on p. 348 of our issue of August 1st, has resulted in a defeat for the plaintiff company. The North American Company, it will be remembered, wanted the Consolidated Company to be forced to use the Johnstone system of conduits and pay $2,500,000 damages for the failure to use the system. It also wanted an injunction pending the determination of the suit to restrain the Consolidated Company from laying or maintaining any other system of underground conduits than those of the Johnstone system. Judge Beach, of the New York Supreme Court, before whom the motion for the injunction was argued, gave his decision on August 11th, refusing to grant the injunction.

The Rating of Laboratories.—Amongst the appeals just decided by the Camberwell Assessment Committee is one of more than local interest, viz., whether an observatory or laboratory built in the grounds attached to a gentleman's residence for purposes of observation and scientific research, can be said to add to the annual value of the premises. Sir Henry Bessemer, at considerable cost, erected, not long since, an observatory in his grounds, and in due course the overseers assessed it at £100 gross value. Mr. Blanch contended, on behalf of Sir Henry Bessemer, that while the observatory was doubtless a source of amusement and instruction, if the house and grounds were in the market to-morrow a great difficulty would be experienced in finding a tenant who would use the

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observatory. The building would probably be got rid of at the earliest opportunity, for an observatory was not altogether a "thing of beauty." In the end the Assessment Committee made a substantial reduction on the assessment.

The Magnetic Field in the Jefferson Laboratory.—This laboratory of the Harvard University has one wing specially constructed throughout of non-magnetic materials, so as to adapt it for delicate magnetic or similar research. To test the efficacy of the precautions which had been entered into in the construction of the building, which is 60ft. square and three floors in height, the variation of the horizontal intensity in the magnetic field over the first floor was carefully determined. The result showed that the intensity was far from constant; in general, the variation from the mean intensity did not exceed ½ per cent., though in one room, between two neighbouring piers about 6ft. apart, it amounted to 4 per cent. The principal causes of this variation were traced to certain vertical iron pipes outside the building used for warming purposes, and also to an iron stove used for experiments on the floor above. The brick piers, or instrument pedestals, were also found to be sufficiently magnetic to produce the variations otherwise unaccountable.

The Preservation of Fermented Liquids by Electricity.—Dr. G. Foth has recently published a very exhaustive series of experiments on the subject. His results led to the following conclusions:—(1) Alternate electrical currents, which, when conducted through a liquid, do not decompose it, are not able to kill yeast cells suspended in the liquid. The electrical current, therefore, as such does not exercise an injurious effect on yeast. (2) This effect is first exercised when the liquid in which the yeast is suspended is decomposed by the electrical current. (3) The ozone produced in the latter case is, if not the only, at all events the principal cause through which the death of the yeast is brought about. (4) The electrical current can, therefore, not be employed to kill the yeast in fermented liquids if their chemical properties are to remain unaltered. Electricity, therefore, cannot be used for the preservation of fermented liquids like beer, unless (5) a higher temperature is brought about by means of alternate electrical currents, in fact unless pasteurisation is effected.

Telephonic Communication with Ships.—An experiment was recently made at Madras, of connecting the Telephone Exchange with the s.s. "Clan McArthur." A wire was laid from the Telephonic Exchange to the T end of the pier. At the T end was an iron stand 3ft. high, to which was attached a drum, round which was wound some G. P. covered wire of seven strands of 16·6 gauge. This cable was connected with wire from the Exchange by a brass trap which came in contact with a brass ring which moved round with the drum. The far end of the cable was attached to No. 1 buoy, and was carried thence along a hawser to the stern of the "Clan McArthur," and connected with a desk instrument. The connection between the "Clan McArthur" and the shore was completed in about two hours, and the communications with the Telephone Exchange were highly successful. If sufficient encouragement is held out by the Port and Harbour Trust authorities and the merchants, it is intended to fix a cable to each of thebuoys of the harbour.

University College, Bristol.—We have received a copy of the Calendar of this College for the Session 1890-91, which begins on October 1st. Great attention has evidently been paid to the engineering department, and the time-tables of the mechanical and electrical engineering courses show that the students are given every opportunity of practically applying their book-learning in the workshop and laboratory. A mere knowledge of testing and laboratory work is, however, not sufficient to enable a student to become an electrical engineer, and arrangements have lately been made whereby students will be enabled to spend one or two terms of six months in works during their College career. Many of the local engineering firms have recently consented to give entrance scholarships to their works, and we are glad to learn that negotiations are still being made to bring closer the connection between the College and leading engineering works, for by this means alone are we likely to extract the maximum of advantage from the system of technical education to which we are now committed.

The Stella Mining Lamp.—This lamp is about to be tried by the Mining Company of Anzin, in France, in one of the most dangerous galleries at the bottom of the mine. The lamp weighs about 3½lbs., and gives a light equivalent to about one candle. The current, which is obtained from an accumulator, is supposed to last about 12 hours perfectly constant, but it is capable of being maintained for about 14 or 16 hours. The accumulator consists of two ebonite cells, each containing five plates 3in. by 1¾in., so arranged as to be protected from exterior shock. Two of these plates are of solid per-oxide of lead (known as lithanode), weighing about ½lb., and have a capacity for useful work of seven ampere-hours. The three other plates are of spongy lead, held in position by a light support of high conductivity. It is stated that the more the lithanode is recharged the better it becomes. Whilst working in the mine the incandescent lamp requires about 5 ampere-hours for twelve hours' lighting. It is claimed that the lamp is absolutely safe, and that when plunged into lighting gas much more explosive than fire-damp did not produce any explosion.

Insects and Arc Lights.—Prof. Lintner, State entomologist, has, says the *Scientific American*, made a microscopic examination of the insect collections of a single electric light, and estimates that the *débris* which he inspected represented 33,000 insects. As many of the smaller forms of insect life probably constituted the larger portion of those attracted to destruction by the light, he believes that the average number of insects destroyed in a night by a single electric light is nearly 100,000. The larger portion of Prof. Lintner's specimen collection from one light consisted of minute gnats, midges, crane flies, and similar small two-winged insects. No mosquitoes were discovered among the victims. There were, however, large numbers of plant bugs, which are injurious to vegetation. A number of the moths, and one of the leaf rollers which have made such havoc in the fruit trees this season, were found, as well as other species of the same family. Prof. Lintner, in speaking of his examination, said: "The electric light will undoubtedly prove an active agent in the reduction of insect pests, and also furnish entomologists with many rare specimens and with many species never before seen."

St. Elmo's Fire.—The occurrence of St. Elmo's fire at sea has been lately studied by Captain Haltermann, of Hamburg, who made examination of a number of ships' log-books for 1884 and 1885, reporting 156 cases, in 800 months of observation. He finds a greater number of cases in north than in south latitudes. And of 63 cases observed in the North Atlantic (the stormiest sea in winter) 49 occurred in the months November to April. Of the total (156) only 27 were unaccompanied by thunder and lightning. Snow and hail showers, with strong wind, seemed specially favourable. As to wind, there were instances with all degrees of intensity. The wind was in most cases (beyond 35° lat.) from equatorial direction, and this, with the commonly observed decrease of pressure, indicates that the cases mostly occurred in the front part of depressions. Between the equator and 10° N. lat. 12 cases were observed, and not one in the corresponding region to the south, where the trade wind generally prevails. In the region of the constantly blowing trade wind St. Elmo's fire is never met with. The western half of seas extending polewards from 30° lat. seems to afford the best conditions.

Gear Wheels for Electrical Traction.—After many experiments there is an inclination in the United States to return to the old-fashioned wooden cogs for speeding down motors. The devices which have been tried with the view of lessening noise have generally been found to wear badly. Well-made hornbeam cogs, gearing with cast iron, have been used in this country for many years, and when well greased will sometimes wear less than the iron. The teeth which are used in the gear which is being tried now in America are driven in with white lead, and wedged at the base in the usual way. They are then put into the gear cutter, and shaped in the ordinary manner. The rim, which is made of cast-iron, slips over the blank, being held in place by six bolts. Between the rim and the hub is laid a sheet of oil paper, which prevents corrosion and tends to stop vibration or "bell tone" from the gear. The blank is keyed firmly to the intermediate shaft, and need never be removed;

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after the wooden teeth have become entirely worn out, all that is necessary is to remove the six bolts and slide off the rim. An extra rim with the teeth in it can then be put on, the entire change not occupying over ten or fifteen minutes. An ordinary carpenter or wheelwright, it is asserted, can recog the old rim and cut the teeth in a half day's time.

The Willatt Electric Drill.—An electrical drilling machine, designed by Mr. W. H. Willatt, electrical engineer to the firm, has just been brought into operation at Messrs. Earles' Shipbuilding and Engineering Company's Works. It has been designed for use on H.M.Ss. "Endymion" and "St. George" (now being built at Earles'), its special purpose being to drill the holes in the 2½in. steel protective decks to receive the armour bolts. This deck is curved and sloping, and thus renders drilling by hand or machine very difficult. The drilling machine stands on three legs, each of which are powerful compound electro-magnets, and capable of lifting 1,000lb. of iron apiece, and have eccentric wheel castors attached to each leg, so that the machine is quite portable. When the machine is brought over the place required to be drilled, these eccentric castors are turned up, thus allowing the magnets to come into contact with the steel deck; the current is then switched on, and they grip to the deck without any further bolting down. The machine carries an electric motor for driving the drill. A hole 2⅜in. in diameter can be drilled through the 2½in. steel deck in 21 minutes. In the Royal Dockyard, at Devonport, to drill similar holes in a similar ship it takes two men half a-day. The current is obtained from the electric light mains, fitted to light the numerous compartments of the ship during construction.

Science Scholarships.—The Commissioners for the Exhibition of 1851 announced some time ago their intention of appropriating an annual sum of not less than £5,000 to the establishment of scholarships to enable the most promising students in provincial Colleges of Science to complete their studies, either in these colleges or in the larger institutions in the metropolis, it being intended that these scholarships should be a supplement to, and not in competition with, scholarships already existing. It has now been decided to allot 17 scholarships annually. The first list of institutions invited to nominate scholars includes eight English, four Scotch, one Welsh, two Irish, one Canadian, and two Australian institutions. The present allotment is to be considered experimental and temporary, and the selection now made of institutions to which nominations are offered will be subject to modification in the future, having regard not only to the manner in which the nominations are exercised, but also to the claims of other universities and colleges which may from time to time be brought before the notice of the Commissioners. The scholarships are to be of the value of £150 a year, and will be tenable for two years, but in rare instances may be extended to three years by special resolution of the Commissioners. They are to be limited to those branches of science, such as physics, mechanics, and chemistry, the extension of which is specially important for our national industries. The scholarships will be tenable in any university either at home or abroad, or in some other institution to be approved of by the Commissioners, and the holders must undertake to devote themselves wholly to the object of the scholarships, and not to hold any position of emolument during their continuance.

A New Photometer.—A civil engineer, M. Lion, recently described an ingenious photometric balance before the Société d'Encouragement. The action of the instrument is based upon the action of light on iodide of nitrogen. The iodide is prepared by the reaction of ammonia upon iodine. It can be manipulated without the slightest danger when it is kept in its mother liquor, and, when exposed to light, the nitrogen set free is proportional to the intensity of illumination. The liberation of the nitrogen begins immediately the light is applied, and ceases as soon as it is withdrawn. The apparatus consists of two closed metallic vessels, the bottoms of which are of glass. Two mirrors, inclined at an angle of 45°, cause the horizontal rays from the sources of light to strike these glass cups containing the reagent in a vertical direction. The two vessels are connected by a very sensitive differential pressure gauge. Before using the instrument, equality of pressure is obtained in the two arms of the gauge by the manipulation of appropriate pistons. If the two reagents are equally illuminated they will give off equal volumes of nitrogen, and the two columns of the manometer will remain at the same level. On the other hand, if there is an excess of pressure on one side or the other it will be indicated by an alteration in the levels of the manometric columns. The source of light which it is desired to compare with the standard is then moved about until a balance is obtained. As the apparatus is always in some degree dissymmetrical, in the same way as a balance can never be considered to be rigorously true, it is necessary to employ something corresponding to double-weighing. The reagents are, therefore, illuminated in turn by the standard light and no balances are obtained. The instrument is made by MM. Alvergniat, of Paris.

Efficiency of the Transformer.—Prof. Ryan replies in the *Electrical Engineer* of New York to the letter of Mr. Swinburne, of which we gave an abstract last week, as follows:—"Mr. Swinburne's letter is as kind as it is just. In determining the instantaneous currents in the primary of the transformer, Mr. Merritt and I used the following method:—Two lamps were selected to be used in the primary of the transformer and 'calibrated' for this purpose by subjecting them to different continuous differences of potential, and observing the corresponding strengths of current that were set up through them. From these observations, then, as data, a curve was determined from which we could read the resistances of the lamps corresponding to any difference of potential throughout the range through which they might be used. The lamps were then used in the primary of the transformer in the manner described in the Paper. When a curve of the differences of potential that were caused by the primary currents producing falls of potential through the lamps was determined, the effective difference of potential was also observed with the electrometer by connecting it direct to their terminals. This effective difference of potential could also be obtained from the same curve of instantaneous values of differences of potential, the two determinations making an excellent check. Then by reference to the curve of calibration the resistance of the lamps was obtained corresponding to the effective difference of potential, assuming thereby that the resistance of the lamps was the same, whether the lamps were subjected to a certain continuous difference of potential or the same numerical effective difference of potential. The ordinates of the curve of instantaneous differences of potential about the lamps were then divided by this value of the above resistance when the resulting curve was the curve of primary current. The correctness of the method then is dependent upon the assumption that the temperature, and, therefore, the resistances, of the lamp filaments remain constant throughout a complete cycle, and from cycle to cycle. Messrs. Humphrey and Powell considered the abstract of a portion of their work that they prepared to read before the American Institute of Electrical Engineers incomplete without a determination of cards of static hysteresis, and of hysteresis and Foucault currents combined, at the periodicity the transformer was worked. These cards they produced in great haste, and by them made the deductions to which Mr. Swinburne calls attention, and incorporated the same in the Paper. They sent their Papers to the Secretary of the Institute to be reported and to have copies prepared for the meeting, and then discovered an error in the determination of these cards. It was then too late to remedy the matter. For these reasons then the plates XII., XIII., and XIV. (*Electrician*, p. 280, Fig. 2, and p. 281, Fig. 5), containing comparisons and deductions from these cards in their Paper, are erroneous and will be stricken from the authorised report of the Institute. The hysteresis loss that Mr. Merritt and I found in the core of the 10-light transformer at a maximum magnetisation of 3,850 lines per square centimetre, was 3,300 ergs per cycle per cubic centimetre, while Ewing's values given for very soft wrought iron, at this same maximum magnetisation, show a loss of about 1,500 ergs, or, roughly, half what we obtained. It is not clear, therefore, why Mr. Swinburne should say that the loss that we found is small."

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MAGNETISM IN IRON AND OTHER METALS.*—XXIX.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 430.*)

§ 108. **Effects of Temperature on Magnetic Quality: Loss of Magnetic Quality at a High Temperature.**—It has been known from the time of Gilbert that when iron or steel is heated to bright redness it loses the power of either retaining magnetism or having magnetism induced in it, but recovers its susceptibility on cooling. The same things happen at a higher temperature with cobalt and at a lower temperature with nickel. In general, the change from the magnetic to the non-magnetic state occurs somewhat suddenly as the temperature is raised. Thus, in one of the experiments of Hopkinson—to be referred to presently in more detail—a piece of wrought iron, subjected to the action of a weak magnetic force, was found to be highly susceptible so long as the temperature did not exceed 775°C. In fact, up to this point the effect of heating was to increase the magnetic susceptibility, and at the temperature 775°C. it was many times greater than when the iron was cold. But with further heating an extremely rapid loss of magnetic quality ensued; when the temperature had risen only 11deg. higher, to 786°C., the iron had become practically non-magnetic. Its permeability was then only 1·1, whereas at 775°C. it had been no less than 11,000. If the test be made with a strong magnetic force instead of a weak one the change from the magnetic to the non-magnetic state is less abrupt†, but it is equally complete, and the same temperature as before makes the iron non-magnetic. Hopkinson calls this the *critical temperature*. The value of the critical temperature varies in different specimens: in samples of ordinary iron and steel it has been found to range from 690°C. to 870°C.‡ In an impure specimen of nickel examined by Hopkinson the critical temperature was 310°C.§

§ 109. **Change of Physical State at the Critical Temperature.**—The change from the magnetic to the non-magnetic state which iron or steel undergoes at the critical temperature is only one of several evidences that the metal then suffers a profound change of constitution. The change shows itself in the alteration of other physical qualities as well as those that have to do with magnetism. Thus Tait‖ has found that the thermo-electric quality of iron alters in a remarkable way at a red heat. The alteration takes place suddenly, and there is no reason to doubt that it is associated with other changes that are brought about by raising the temperature to the critical value. Again, as the experiments of W. Kohlrausch¶ and Hopkinson** have shown, the critical temperature is marked by a sudden change in the coefficient which expresses the effect of temperature upon the electrical resistance of iron. The same thing is true of nickel. Perhaps the most striking evidence that when iron reaches the critical temperature it passes—more or less suddenly—from one condition to another widely different condition, is furnished by Barrett's discovery of "recalescence."†† Let a piece of iron or steel be heated to bright redness and allowed to cool slowly; at a certain stage the process of cooling experiences a sudden check. Heat is generated within the substance of the metal as a consequence of the change which the molecular constitution suffers at this critical point; the cooling is arrested, and the temperature may even rise, though the loss by radiation is going on as before. It is in hard steel that the phenomenon is most marked. So much heat is generated while hard steel passes from one molecular state to another at the critical point, that there is a very visible reglow; the surface of the cooling metal turns for a few moments from a dull to a much brighter red, after which the colour continues to fade. The point at which recalescence takes place is the point at which the cooling metal returns from the non-magnetisable to the magnetisable state. This fact, which was surmised by Barrett, has been proved by the experiments of Hopkinson, who has measured the amount of heat liberated during the change, and has, moreover, given further proof that recalescence has an intimate connection with the recovery of magnetic quality, by showing that it does not occur at all in non-magnetisable manganese steel.*

§ 110. **Effects of Temperature below the Critical Point.**—In studying the effects of temperature we may adopt one or other of two distinct methods. We may note the changes of magnetism which are brought about by varying the temperature, while the magnetic force is kept constant; and as a special case of this we may note the changes of residual magnetism which are brought about by varying the temperature when there is no magnetic force in action. Or we may compare the amounts of magnetism which are acquired at one and another temperature when the specimen is brought to the temperature in question before the magnetic force is applied. In other words, we may determine the form which the curve of I or B and H assumes, when the one or another temperature is maintained constant throughout the process of magnetisation, and may compare the curves got in this way at various temperatures. The two methods do not yield identical results, because of the tendency which the magnetic metals exhibit to oppose magnetic change—the property, namely, which gives rise to those effects which are included under the general name of magnetic hysteresis. On account of this property, which all the magnetic metals share more or less, the magnetic condition that is arrived at if we heat the specimen to any assigned temperature first, and then apply any assigned magnetic force, is in general different from the condition that is reached when the order of these two operations is reversed. The same remark applies with respect to the changes of magnetic quality that are brought about by altering the state of stress, or any other physical condition on which the magnetic state of the specimen depends. In the most complete investigations which have yet been made of the effects of temperature on magnetic quality, the plan has been followed of varying the temperature first, and then studying the effects of applying magnetic force. In other words, what have generally been observed and compared are the susceptibilities of the same specimen at different temperatures.

The experiments of Rowland, Baur, and Hopkinson are of this kind. Rowland,† examining the susceptibility of nickel at two temperatures (5°C. and 230°C.), found that at the higher temperature there was much more susceptibility with respect to weak magnetic forces than at the lower temperature, but less susceptibility with respect to strong forces. In other words, when the magnetisation was sufficiently high the effects of temperature upon susceptibility became reversed. The maximum susceptibility, occurring as it does when the magnetic force is tolerably low, was greater at the higher temperature (some 70 per cent. greater at 230°C. than at 5 deg.). In cobalt, again, he showed that the susceptibility with respect to low forces is increased by heating—a specimen in which the maximum susceptibility (κ) was 11·2 at 5°C. had its maximum susceptibility raised to 18·7 at 230°C. The magnetic forces used by Rowland were not strong enough to reverse the effect of temperature in cobalt, but it is now known that under sufficiently strong force the effect is reversed in that metal, as it is in nickel. Baur ‡ has shown that iron behaves in the same way. If we compare the susceptibility of iron at two temperatures we find that the susceptibility is greater at the higher temperature provided the magnetic force does not exceed a certain value, but less at the higher temperature when the force does exceed that value. It is with respect to weak forces that the influence of temperature is most conspicuous. The most complete experiments on the subject are those of Hopkinson, who has given in the two Papers cited above (one dealing with iron and steel and the other with nickel) series of curves of magnetisation at various tempera-

* All rights are reserved.

† Reference should be made in this connection to the experiments of Baur, in the Paper "Experimentelle Untersuchungen über die Natur der Magnetisiringungfunction," already cited. (Wiedemann's *Annalen*, 1880, Vol. XI.)

‡ Hopkinson, "Magnetic and other Physical Properties of Iron at a High Temperature." *Phil. Trans.*, 1889, A., p. 443.

§ Hopkinson, "Magnetic Properties of an Impure Nickel." *Proc.* Roy. Soc. Vol. XLIV., 1888. p. 317.

‖ Tait, *Trans.* Roy. Soc. Edin., 1873.

¶ Kohlrausch, Wied. *Ann.*, Vol. XXXIII, 1888.

** Hopkinson, *loc. cit.*

†† Barrett, *Phil. Mag.*, January, 1874.

* Hopkinson, *loc. cit.* † Rowland, *Phil. Mag.* November, 1874.

‡ Baur, Wied. *Ann.*, 1880, Vol. XI.

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tures, ranging up to the critical temperature at which magnetic quality disappears. A few of his results may be quoted as the best means of giving some account of the connection between magnetic quality and temperature.

§ 111. **Hopkinson's Experiments on the Magnetisation of Iron at Various Temperatures.**—In these experiments the specimens were rings, and the magnetisation was measured ballistically by reversing the magnetising force. The primary and secondary coils were insulated with asbestos paper; the ring was placed in a cast-iron box, and was heated by a gas furnace, and its temperature was inferred from the resistance of the secondary coil, which was measured before and after each magnetic experiment.

A ring of soft wrought-iron, for which the critical temperature had been found to be about 785°C., was examined in successive experiments, at various temperatures, the curve of **B** and **H** being determined in each case, while the temperature was kept as nearly constant as was practicable. The results show that heating the iron to a high temperature (short of the critical temperature) augments its susceptibility with respect to small magnetic forces very greatly. On the other hand, it reduces greatly the effect of strong magnetic forces. For example, a force **H** of 0·075 C.-G.-S. was found to give the following values **B** at the temperatures noted :—

Temp.	10°C.	376°C.	494°C.	603°C.	670°C.	722°C.	744°C.	763°C.	775°C.	778°C.
B	17	41	45	59	120	144	203	294	494	512

At 788°C., the critical point having been passed, the induction had practically sunk to zero. These figures show well

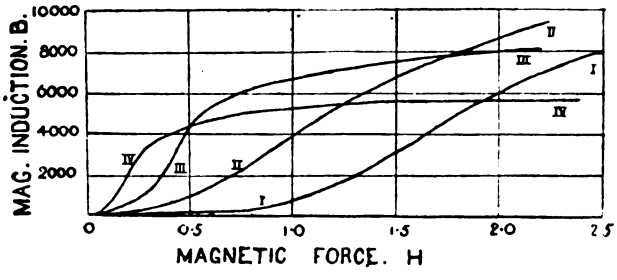

Fig. 77.—Magnetisation of Iron at various temperatures.

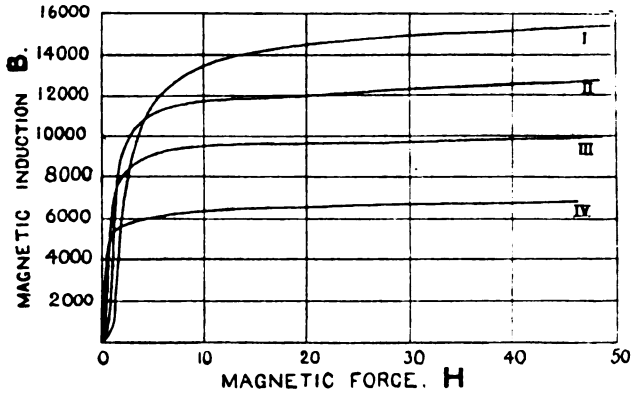

Fig. 78.—Magnetisation of Iron at various temperatures.

the enormous increase of permeability which heating causes at early stages of the magnetising process. On the other hand, a force of 50 units or so gave less than half as much induction at the upper as at the lower end of this range of temperature. Thus the curves of **B** and **H** taken at any two temperatures cross each other, the one for the lower temperature lying at first below and afterwards above the other. Hopkinson has expressed his results in curves of this kind, some of which are copied in Figs. 77 and 78. Curve I. in these figures is for a temperature of 10°C.; curve II. for a temperature of 670°C.; curve III. for a mean temperature of about 742°C. (it varied a few degrees during the observations); and curve IV. for a mean temperature of about 771°C. In Fig. 77 the early portions only are shown; the scale of **H** is wide, in order to display well the crossing of the curves. Fig. 78 shows the

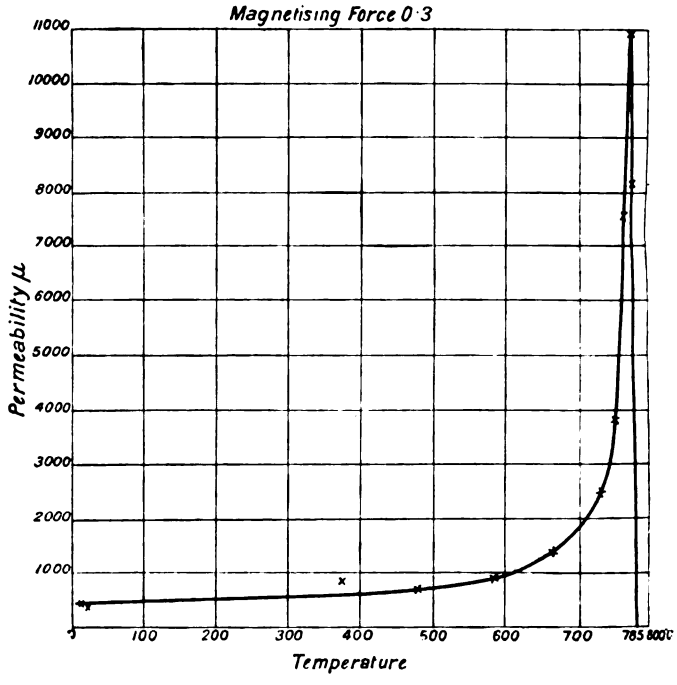

Fig. 79.

whole process of magnetisation with a twenty-fold coarser scale of **H**. The rapid rise and low apparent saturation value in curve IV., where the temperature approaches most closely to the critical value, are to be noted. The same results are shown in a different manner in Figs. 79, 80, and 81, also

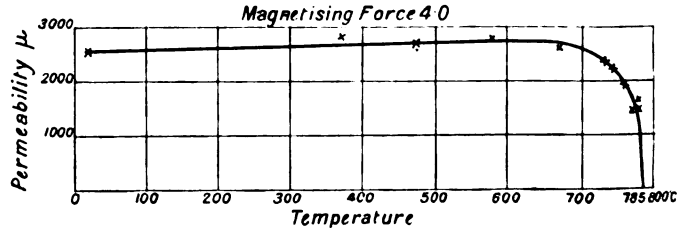

Fig. 80.

copied from Hopkinson's paper. These give the permeability μ in relation to the temperature for three specified values of the magnetising force (0·3, 4·0, and 45). Fig. 79 shows in a striking way the suddenness with which susceptibility to small magnetic force is lost at the critical point, and how this is

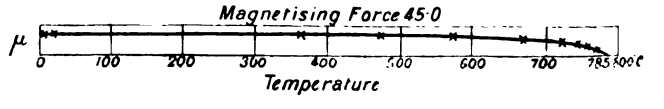

Fig. 81.—Relation of Permeability to Temperature in Iron.

preceded by an enormous augmentation of susceptibility; the other two curves show how much more gradually is the passage from the magnetic to the non-magnetic state when we have to deal with strong forces. In the curve of Fig. 79 the permeability at atmospheric temperatures is 367; as the temperature rises it increases at first slowly and afterwards with great rapidity, reaching the maximum already mentioned of 11,000 at 775°.

(To be continued.)

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ON THE ELECTRO-DYNAMICS OF STATIONARY BODIES.*

BY H. HERTZ.

The collection of principles and formulæ which Maxwell has used for the purpose of exhibiting the theory of electro-magnetic phenomena forms the most complete and most fertile system of all those having the same object in view.

It is much to be desired that a method so essentially correct should be expounded in proper form. The fundamental principles should be stated in a clear and precise manner, the essential deductions should be drawn in the most simple way, and all superfluous notions should be got rid of. Unhappily, Maxwell is far from having attained this perfection in form. He oscillates too often between the reality of facts and the conception of purely hypothetical ideas. Maxwell starts with the notion of forces acting directly at a distance; he seeks the laws according to which the hypothetical polarisation of the ether varies under the action of such forces, and he ends by showing that in reality this polarisation varies without the forces referred to being the cause of the variations. It is clear that such a method does not satisfy the mind, and leaves a prejudice that the result, and the conclusions drawn therefrom, are not correct.

Moreover, this proceeding introduces into the formulæ many principles which are superfluous, and in some respects incomplete, and which are only significant in connection with the old theory of forces acting directly at a distance.

An example of these faulty physical principles consists in the distinction between the dielectric attractions and repulsions and the electric forces acting, as well as the consideration of the ratio of these quantities. These distinctions would have a meaning if we could draw the ether out of the space it occupies, and, at the same time, leave behind the electric forces. According to Maxwell's conceptions, this is perfectly admissible, but it is quite at variance with the ideas gathered from his work.

As an example of incomplete mathematical conceptions I would instance the introduction of the quantity vector-potential into the fundamental equations. In the establishment of our new theory we use potential as a foundation, since by its introduction discontinuous forces acting at a distance are replaced by values determined solely by the state of the medium in the neighbourhood of the point considered. But the substitution of forces by quantities obtained by means of the introduction of vector-potential has only one purpose, that of procuring a mathematical advantage; and it is important that the fundamental equations should state relations between physical quantities rather than relations between quantities used merely for calculation.

This imperfection of form which we have just pointed out renders, in many cases, the application of Maxwell's theory excessively laborious. Thus, when I have had occasion to use it, a long time has been necessary to understand the formulæ, and to distinguish their essential signification. The present Paper embodies the results obtained in my work of revisionand correction.

In 1885 Mr. Oliver Heaviside † worked with the same object in view. The conclusions which he drew from Maxwell's equations are absolutely identical with some of mine, as well as the very simple form which he was induced to give to them. So far, therefore, priority belongs to Mr. Heaviside. In spite of that, I do not consider my work useless. Doubtless the essay is not perfect, but I venture to believe that among all those which have yet appeared mine is that in which most improvement will be found.

I divide the work into two portions. In the first part, A, I expose the fundamental principles and the formulæ following from them. Each formula is discussed, not for the purpose of demonstration, but in order that its meaning and full bearing may be better realised. The groundwork on which I rest is always experience, and the only proof of the formulæ given is experimental. It is clear that each formula cannot be directly demonstrated, but only the entire system of formulæ. The work involves but few equations in addition to those furnished by ordinary rational mechanics.

In the second part, B, I indicate in what way different facts furnished by direct observation can be deduced from the formulæ found, in order to completely establish the correctness of the method.

A.—*Fundamental Principles and their Connection.*

Electric and Magnetic Force.—The interior of all bodies placed in free ether can undergo electric and magnetic perturbations. We do not know the nature of these variations of state, but only the observable phenomena caused by them. We shall suppose these phenomena known, and by their consideration we shall determine the geometrical relations denoting these variations in state. The electric and magnetic perturbations are connected together; for although they may exist at the same time independently of each other, every change of either affects the other. The existence of each perturbation denotes a store of energy, since its change involves a manifestation of energy.

At a given point one can specify the variations of state of each kind with regard to their magnitude, direction, and sense. Consequently, to completely determine either the electric or magnetic state, it is necessary to know either a "directed quantity" or else its three components. We shall, first of all, make an important supposition for our theory, namely, that the knowledge of a single-directed quantity is sufficient to fully determine the variation of the corresponding state. Certain phenomena, such as permanent magnetism, dispersion, &c., are not included in the supposition; for in these cases the electric and magnetic state at any point is determined by more than one variable. Such phenomena are, however, not included in those we propose to consider.

The directed quantity which serves to represent the electric state we shall call the electric force, and define it by means of the mechanical force exerted on an electrified body placed in free space, and submitted to an electric disturbance. For free space the component of the electric force in any direction is represented by the magnitude of the component in the same direction of the mechanical force. For a point within a body, the electric force is defined to be that acting within an empty cylindrical space surrounding the point considered, the cylinder being infinitely thin, and having its axis in the direction of the force.

If we replace everywhere the word "electric" by the word "magnetic," and the electrified body serving for the measurement of electric force by one of the poles of a magnetised needle, we shall obtain the definition of magnetic force.

To fix definitely the sense of direction of the two preceding forces, we shall suppose that the auxiliary electrified body is charged positively, and that the pole of the magnet is the north pole. We shall, for the present, defer the consideration of the units of the two forces.

We shall denote by X, Y, Z the components of the electric force along the axes x, y, z respectively, and by L, M, N the corresponding components of the magnetic force.

Energy of the Field.—The accumulation of electric energy which occurs in a given space is a quadratic function of the three components of the force. This is also true of the magnetic energy. It follows that for an isotropic body, the energy contained in a unit volume is equal to the square of the resultant force multiplied by a constant. This constant may be different for the electric and magnetic energy. We shall measure energy in Gauss' absolute unit, and choose the unit of force so that in free ether the constant becomes $1/8\pi$.

The energy contained in a unit volume of the disturbed ether is then given by the expression

$$\frac{1}{8\pi}(X^2+Y^2+Z^2) + \frac{1}{8\pi}(L^2+M^2+N^2).$$

The dimensions of the electric force are thus the same as those of magnetic force, and are such that their square has the dimensions of energy per unit volume. For isotropic massive bodies the energy per unit volume is

$$\frac{\epsilon}{8\pi}(X^2+Y^2+Z^2) + \frac{\mu}{8\pi}(L^2+M^2+N^2).$$

* An abstract of a paper published in the "Nachrichten von der Königlichen Gesellschaft, der Wissenschaften," for March, 1890; and reprinted in *La Lumière Électrique*, July, 1890.

† See *The Electrician*, 1885, a series of articles on "Electro-magnetic Induction and its Propagation."

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The new constants ϵ and μ are necessarily abstract positive numbers. We shall call ϵ the dielectric constant and μ the magnetic constant of the body. Evidently their values enable us to compare the electro-magnetic energy of one body with that of another. The nature of the body does not alone determine the value of these quantities. We can, if we choose, make this value unity for ether, but it is necessary to remark that this is only an arbitrary assumption, and not an experimental fact.

Relations between the Forces in Ether or in Non-conductors.—We shall suppose our axes so chosen that when looking along the axis of x in the positive direction, y will be positive when measured to the left, and z positive when measured upwards. Under these circumstances the electric and magnetic forces are connected by the equations

$$\left.\begin{aligned} A\mu\frac{dL}{dt} &= \frac{dZ}{dy} - \frac{dY}{dz} \\ A\mu\frac{dM}{dt} &= \frac{dX}{dz} - \frac{dZ}{dx} \\ A\mu\frac{dN}{dt} &= \frac{dY}{dx} - \frac{dX}{dy} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (1)$$

$$\left.\begin{aligned} A\epsilon\frac{dX}{dt} &= \frac{dM}{dz} - \frac{dN}{dy} \\ A\epsilon\frac{dY}{dt} &= \frac{dN}{dx} - \frac{dL}{dz} \\ A\epsilon\frac{dZ}{dt} &= \frac{dL}{dy} - \frac{dM}{dx} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (2)$$

$$\left.\begin{aligned} \frac{dL}{dx} + \frac{dM}{dy} + \frac{dN}{dz} &= 0 \\ \frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} &= 0 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (3)$$

These equations may be obtained either from hypothesis regarding the electric and magnetic constitution of the ether and the nature of the forces acting, or on the basis of known facts. The latter method is much to be preferred, so that the equations can be used to make clear our conceptions of the constitution of the ether.

(To be continued.)

THE HISTORY OF THE COPPER RING.

The fluctuations and changes of the past three years in the Copper Market have illustrated to a degree the old adage that it is the unexpected that happens. Prior to the autumn of 1887 copper for some years had been dropping in price, notwithstanding that the statistical position for a year or two had indicated that consumption was exceeding production, or, at all events, that deliveries were on a larger scale than supplies. It has been asserted in usually well-informed quarters that towards the close of the decadence in price, which culminated in the formation of a syndicate to raise quotations, the market had been artificially manipulated to drive down the price, so that those who had the intention to buy could secure copper at a low level to commence operations from. Be this as it may, in the early autumn of 1887 copper was as low as a few shillings over £38 per ton, and only those mining companies having exceptional advantages of position and richness of deposits could manage to live, and then only at the expense of the shareholders, who in some cases had to go without dividends. Many of the mines shut off work during the period of declining prices; and naturally with a very cheap quotation for the commodity consumption was stimulated just at the same time that production was falling off. According to brokers' statistics, the deliveries for consumption in the 12 months to August 31, 1887, were about 96,000 tons. The supplies amounted to about 81,000 tons, so that there was an excess of consumption over production of about 15,000 tons.

The average monthly deliveries for the 12 months named were 8,000 tons, and the visible stock in hand but little excedeed six months' consumption. There were then the conditions of very small stocks. Retail users of copper had become so accustomed to a falling market, that they too had not cared to work with any appreciable supply, even though assured that they would actually use stores bought To use a colloquial phrase, the market was "bare to the bone;" and yet the use of copper was extending in all the manufacturing industries in general, and in electrical departments of manufacturing industries in particular. Under such conditions the idea of a combination to speculate in copper was not so very wild a scheme, had operators been content with a fair remuneration for the risk they undertook. Under the leadership of a very bold speculator, a combination was formed to raise the price of the metal and control the visible supply. At first this control took the shape of acquiring a considerable amount of the floating supply. Subsequently proposals were made to the leading copper-producing companies in all quarters of the globe to take stated quantities of copper for a period of three years. The scheme was quite French in its elaboration, but a factor was missed.

This factor was the imperishable nature of copper. As soon as prices mounted up to double the quotations, previous to the initiation of the speculation, invisible supplies of copper came pouring into Europe from all quarters. The price made it profitable to melt up all manner of odds and ends; and pedlars even went about in distant countries collecting such out-of-the-way additions to stores of copper as old idols. Thousands of tons of old copper came into the market, and it was estimated that 50,000 to 60,000 tons of second-hand metal was in all accumulated. As the rise went on users of copper sought for means to restrict the quantities they required. The fashion of using brass for household appliances was curtailed. Steel coated with copper was largely used in place of the metal itself, and very quickly there came the feature of production greatly exceeding consumption.

The electrical trades were very seriously embarrassed, as they have no alternative but to use copper, and that of the highest quality. The projected copper telegraph lines of the General Post Office had to be abandoned for the time, although the few which had been erected had proved to be highly satisfactory.

Here are the facts of the second great change in statistics. From October 1, 1887, to the end of September the year following, brokers' lists gave 125,000 tons of supplies (irrespective of invisible stocks thrown on to the market in the shape of remelted copper), while the consumption only reached about 83,000 tons, an excess of supply over consumption of about 40,000 tons, or about 50 per cent. of the total deliveries. Late in 1888 it became apparent that the group who had associated themselves together to control the Copper Market had undertaken a task beyond their strength. Early in 1889 a similar combination in the tin trade broke down, and in March, 1889, the copper combination broke up.

It is in the recollection of everyone what a smash there was in Paris early in March last year. The price of copper, which had ranged about £78 per ton at the close of 1888 and early in 1889, suddenly fell at the close of March to below £40 per ton, momentarily touching £35 per ton, the lowest price in the history of the industry. For some considerable while it did not recover to over £40. Once again statistics changed very remarkably. The brokers' lists indicated that the stocks between the lowest point at which stock stood in 1887 and the highest to which they rose in the early part of 1889, had advanced from a little more than 40,000 tons to about 125,000 tons; and besides the 125,000 stocks which were known of early in 1889 the Paris syndicate held some 50,000 tons "invisible supply," presumably representing the accumulations of old pots, pans, kettles, and idols.

When the break occurred in the market some of the most powerful financial institutions in Europe, particularly in Paris, who had made advances to the syndicate on the security of copper, had involuntarily to take over the speculation for their own account, owing to the failure of the Société des Métaux, which was the head and front of the combination. Under the conditions of the disorganised market any attempt to have sold copper at the time, or immediately after the collapse, would have been impossible. The strong financial houses, therefore, decided to nurse their holdings, and have eventually been suc-

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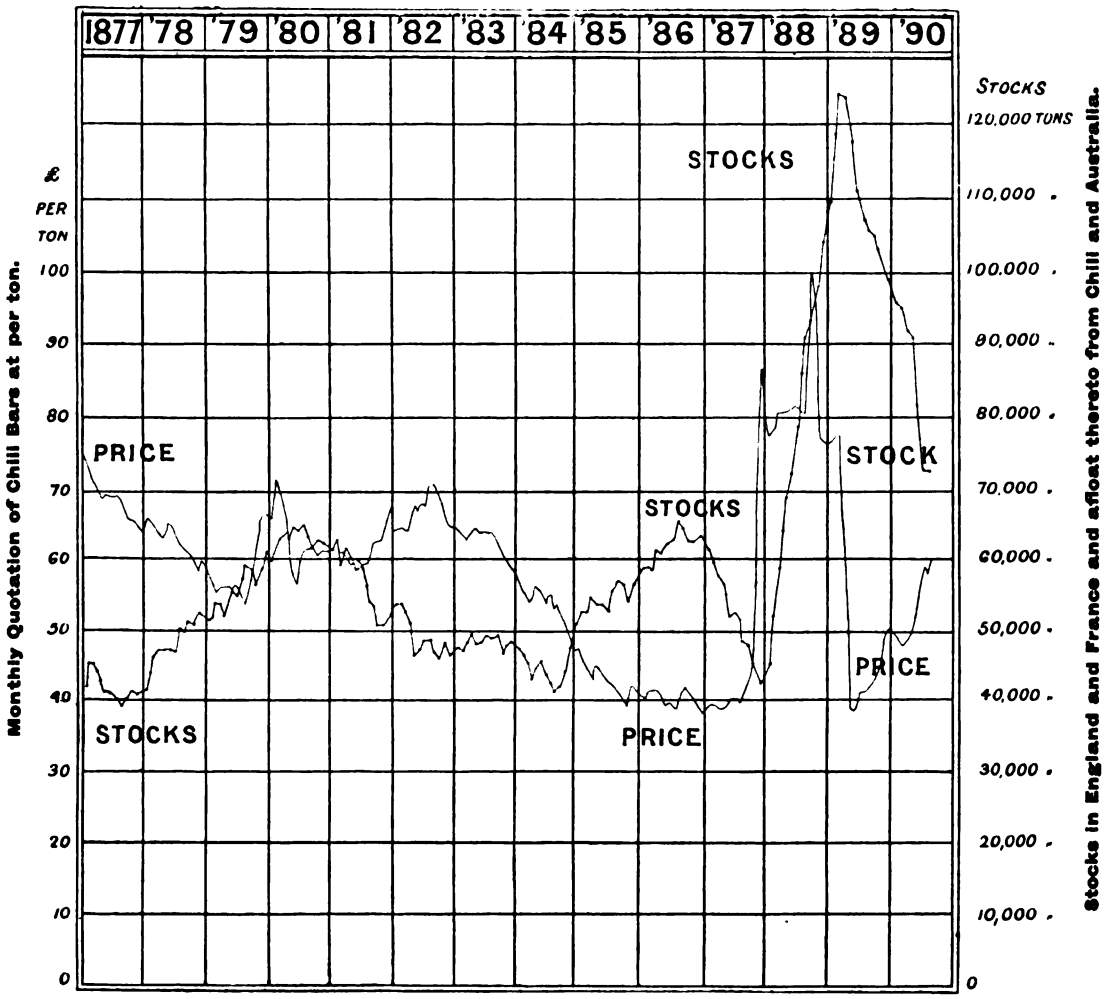
COPPER.

DIAGRAM *showing since 1877, inclusive, the Approximate Course of the Price of Chili Bar Copper (price at the close of each month), and Stocks of Copper received and afloat.*



cessful in disposing of pretty well all without loss, and some indeed at a profit.

Just the very reverse of what happened when copper was rising in price happened when the collapse took place. Consumption was stimulated, production fell off, second-hand supplies had been mopped up, and the market having since been left to the conditions of legitimate trade, supply and demand, the industry has gradually emerged from the chaos brought about by the reckless speculation carried to extravagant lengths by M. Secretan and his friends. Once, again, taking 12 months' supplies and deliveries, we find the fact of a greater consumption than ever before in the history of the trade. The amount delivered to the trade for 12 months to July 31st last was 152,000 tons, and the supplies only reached a little more than 116,000 tons. The bankers and others who were holders of copper have been particularly favoured from the circumstances of activity of trade and a great development of the shipbuilding industry during the last few months. The use of copper, too, has extended very considerably owing to the development of requirements of the metal for electrical purposes. The position is now sounder than it has been for a long period. The average consumption per month of the past 12 months has been not far short of 13,000 tons a month, and the stock of about 72,000 tons consequently represents less than six months' consumption. Owing to the statistical position the price of the metal has been steadily appreciating, until we have this month had it quoted within a trifle of £60 per ton for cash, and over that price for ahead. After the experience of the past we may expect more moderation in market speculation, and the healthy recovery has evidently been due to a belief that with growth of trade and uses for copper the consumption is likely to continue to steadily increase, while few people will be rash enough to seek to control production in such a manner as was attempted in the memorable operation of 1887-9.

We supplement the above remarks with a diagram of statistical information as to the course of stocks in the past and movement in price of copper. Every minute fluctuation in price cannot of course be indicated, so we merely give the quotation at end of each month. The stocks are as given in Messrs. Merton's monthly statistics. Each horizontal space in the diagram represents £10 of price and 10,000 tons of stock. The highest and lowest prices touched in each year supplement the features shown in the diagram, and are added below, as well as figures of the highest and lowest stocks :—

—	Prices.		Stocks.	
	Highest.	Lowest.	Highest.	Lowest.
	£	£	Tons.	Tons.
1877	76	63	46,100	40,500
1878	66¼	55	53,400	44,400
1879	67½	53	58,400	52,200
1880	74½	54½	65,000	59,600
1881	72½	57	62,400	50,200
1882	72	62½	54,000	46,800
1883	67½	56¼	49,900	46,800
1884	57¾	47¼	47,800	40,800
1885	49¼	38¼	57,200	51,400
1886	43¾	39 5/8	66,100	58,500
1887	83½	38¼	61,400	42,300
1888	107½	73¾	104,100	45,500
1889	80¾	35	124,900	98,800
1890 to date	60¼	46	95,700	72,500

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SPECIAL NOTICE.

With the Next Number of "THE ELECTRICIAN" we shall issue a fine STEEL PLATE PORTRAIT of Dr. OLIVER J. LODGE, F.R.S.

BOARD OF TRADE SAFETY REGULATIONS.

The long-expected regulations "for securing the safety of the public, and for ensuring a proper and sufficient supply of electrical energy," have been issued. They are not on sale at the Government printers, and only fifty copies appear to have been printed. A copy of these regulations will be issued with and will form part of all Provisional Orders in the future. The copy before us is "made by the Board of Trade under the provisions of the Electric Lighting Acts, 1882 and 1888, and of the NOTTING HILL Electric Lighting Order, 1889." The KENSINGTON AND KNIGHTSBRIDGE Company had a draft set of rules which correspond in many particulars to the present regulations, in June last year; and since that time they have been gradually worked into shape. They were submitted by the Board of Trade to the Council of the Institution of Electrical Engineers; but a request from the Electrical Trades Section of the London Chamber of Commerce for permission to see the draft, and to offer comments on it, was refused. Fortunately the former body was not the only source from which suggestions were invited, but copies were sent to the supply companies. The details had been considerably modified when we published the draft as it stood at the beginning of this year (*Electrician*, Vol. XXIV., p. 275). It received further alterations on behalf of the requirements of the Postmaster-General, and it has since been for some months in the hands of certain local authorities. An early form of the rules demanded that transformers should be completely enclosed in metal casing not less than one quarter of an inch in thickness. This clause would probably affect Messrs. SWINBURNE and Co. more severely than anyone else, as the stray induction from the bristling ends of their hedgehogs would give rise to serious losses if surrounded by metal. But not only the transformers had to be so enclosed, but "the whole of the high-pressure service lines, conductors, and apparatus, so far as they shall be on the consumer's premises," were to be so enclosed. This extraordinary suggestion has been abandoned, and the much more sensible demand for enclosing them completely "in solid walls or in strong metal casing efficiently connected to earth, and securely fastened throughout," has been substituted.

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There is one respect in which the supply of electric energy differs widely from that of gas and water; and one in which those who framed the regulations must have found themselves without any precedent. A leak on a gas service is not a matter of concern to the gas company if it is on the consumer's side of the meter. The consumer will be, as a rule, amply warned by the smell, and explosions are generally due to some additional carelessness. Indeed, in gas or water supply, a leak on the consumer's premises is a distinct source of revenue to the company, if a meter records it; but an earth on an electric supply circuit is not only a matter of considerable inconvenience to the electric supply company, but may have undesirable effects on the other consumers, and on neighbouring telegraph and telephone systems. On this account, rule 23 authorizes the intrusion of an officer on the premises in which the supply company are "reasonably satisfied" that a leak exists to earth, which may be a source of danger.

The property of the consumer in his wires, and that of the supply company in their service lines, meet at a point which is distinctly specified in the definitions as the "consumer's terminals." But the rights of the supply company do not stop here. An inspector may "require the consumer to permit him to inspect and test the wires and fittings belonging to the consumer." This language is suggestive of the unwelcome courtesies of the highwayman, who, with all the politeness and graces of his time, was wont to ask for permission to inspect the purses of travellers when he was reasonably satisfied that they would be a source of wealth. The inspector, moreover, may at all reasonable times, after giving one hour's notice of his intention to do so, enter the "suspected premises" for the purpose of "discovering whether such connection with the earth exists at any part of a circuit." The definitions do not attempt to define what shall be a reasonable time; the notice may evidently be served an hour before the time has become reasonable. The object of this visit of discovery is a leak to earth not exceeding 5,000 ohms. Now, without interfering with the consumer's wires, and certainly without any pottering with his fittings, the officer might easily make his test by disconnecting the supply company's service lines from the neutral landmark of the consumer's terminals, and might test from these to earth, the consumer's wires remaining attached to his terminals. The gas companies' boundary is the main valve or cock; and the limit of the water companies' property is similarly defined. Without going into the question as to who should pay for a switch, it appears that either a double-pole switch, or, preferably, two switches, or a pair of terminals from which the company's service lines can be readily removed, should be the definite limit both of property and of rights. Should it be discovered that a leak to earth exists on the consumer's wires, the company's service lines would not, of course, be re-connected. Since the supply company would not wish to let matters stand thus, the inspector might offer to make further tests or examination of fittings; but permission should be asked for and should be granted before this ought to be done.

We all grumble at the waterworks; they are associated with rates and taxes, while the gas companies provide us with a machine which is the proverbial standard for deliberate falsehood. The electric supply companies should avoid making themselves unpopular; and this compulsory inspection, if it extends to wires and fittings, might be even more objectionable than the occasional disconnection from the mains for the purpose of localising an earth by trying one house or street after another. On June 3rd last year a draft set of rules for use at Bradford was submitted to the Electrical Trades Section, and a few days later these were to be obtained from the Town Clerk, and objections were invited. These rules prohibited the use of any portion of the metal work of electrical fittings as part of the circuit, and demanded an insulation resistance, equal to ten megohms, divided by the total current in amperes. Should any "connections direct with earth, or connections tending to cause earth," be found at any time to exist in an installation, these rules allowed the Corporation to discontinue the supply, even without notice. There is no suggestion of any compulsory "permission" to test the wires and fittings of the consumer. The ninth rule of the Bradford Corporation demands two main switches; and the tenth states that "the proper officers of the Corporation shall have the right of access at all times to these switches." It is a pity that it has been proposed to go beyond this. If the house were shut up, it should not be a difficult matter to disconnect at the junction box; or, where this would occupy too much time, it would be easy enough in most London houses to place the switches within reach of a long key which could be used from outside. The most important matter for public convenience is to disconnect the house, if there is but little doubt that it has a leak; the next thing, for the convenience of the consumer, is to prove the existence of the leak by a test at his terminals, but, to go further and officiously meddle with wires and fittings without his voluntary consent is objectionable. The new rules are much more reasonable than those of Bradford in defining a leak as a connection having a resistance not exceeding 5,000 ohms; but there is a danger that, as in the minimum thickness of walls specified by the Metropolitan Building Act, it may be assumed by those who do cheap work that 6,000 or 8,000 ohms is a decent insulation.

The rules as they now stand will be received with less dissatisfaction than the overhead wire rules, but, as in the former case, some difficulties may arise hereafter when they are put in practice. The overhead wire rules have been incorporated in the new regulations with certain modifications, parts of some of them being transferred to the "definitions." The first regulation of the former set appears as No. 26 of the new issue; the height at which a conductor must cross a street being altered from thirty to thirty-five feet, and the minimum distance from a building being seven feet instead of six. The distance of six feet has been very troublesome to arrange in several cases already, and the change seems to indicate that the Board of Trade do not scruple to throw obstacles in the way of overhead wires. It is to be regretted that the rules relating to aerial conductors have been thus confirmed, since a struggle against the insulation specified in Rule 33 will certainly be carried on; and it is to be hoped that the Board of Trade will confess that they made a mistake in stipulating for an article which they had never seen, and which when made was ridiculous. Rule 27 is a new one. Rule 32 is the same as before, and contains no suggestion as to the method by which it is to be carried out. It was once threatened, unofficially, that a length of rabbit netting would have to be placed under each wire to catch it in case of breakage.

On the whole, the new rules appear to be satisfactory. They do not in any way supersede those of the fire insurance offices, nor will they be likely to render unnecessary those regulations by which the supply companies now protect themselves. They appear to leave but little to the discretion of the inspector; and though they do not exhibit the broad spirit which is noticeable in the other regulations of the Board of Trade, such as those for railways, it may be expected that when things settle down and more experience has been gained, those demands which are found to be unreasonable will be modified, and the rules will not then press hard upon those who do first-class honest work.

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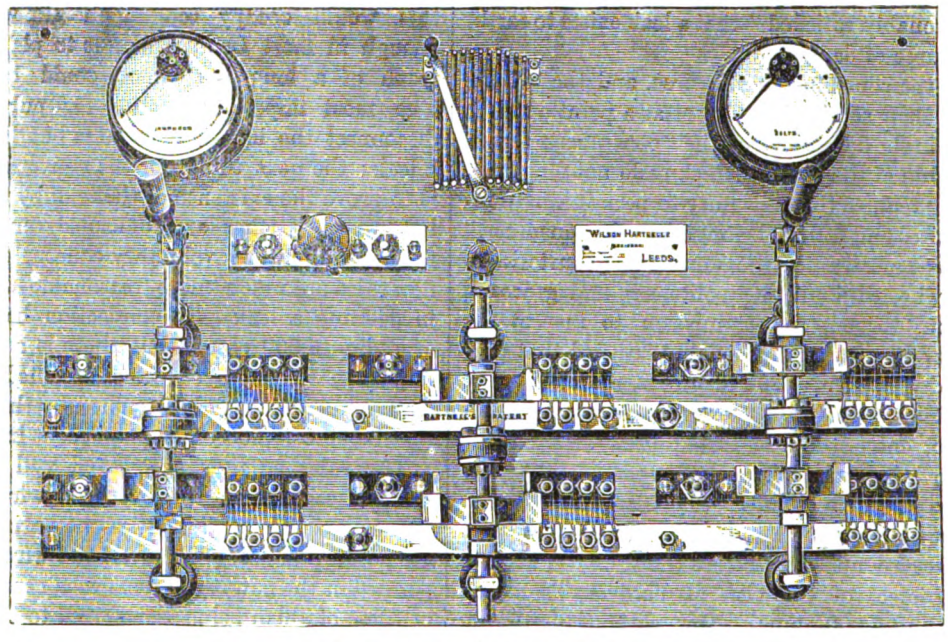
THE EDINBURGH EXHIBITION.—IV.

Mr. Wilson Hartnell's Exhibit.

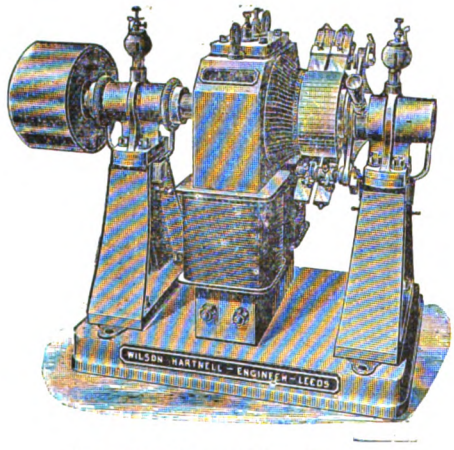
Mr. Wilson Hartnell, of Volt Works, Leeds, occupies a space of some 20ft. by 10ft, in the Machinery Hall. He shows one of his wrought-iron dynamos running at 960 revolutions, and capable of supplying 280 16-candle 64 watt lamps. This is driven by a 6 horse-power horizontal engine by Marshall, Sons, and Co., fitted with Hartnell's automatic expansion gear. Alongside the dynamo is placed a 15 horse-power motor, which is driven from the above machine at a speed of 1,000 revolutions per minute. These dynamos are strong and well made, with large bearings, armature, commutator, and spindle, and they run without any signs of sparking. The one shown has run from the commencement of the Exhibition, with a load equal to about 200 lamps almost continuously; and measurements recently taken show that there has been no wear at the commutator or brushes. The latter have never been touched in any way since starting.

The current is taken from the dynamo to one of Hartnells' patent distributing switchboards, containing three double-pole quadruple break switches, made for carrying 200 lights on each circuit. This is also furnished with ammeter and voltmeter and short circuit plug, as also with a neat variable regulator, which latter is extremely useful for dynamos running all night long. Double pole safety fuses are also employed, and the whole is mounted on a substantial enamelled slate base. The workmanship is of the highest finish. A second switchboard is also shown of three circuits for a smaller installation, and, in addition, there is a motor switchboard in use for the motor already alluded to. Specimens are also shown of Hartnell's patent double-pole switches, such as are suitable for private house lighting, in which all the connections are made on the front of the slate for safety and convenience. No metal work projects on the back side of the slate, it being recessed, and for the most part covered up entirely.

The stand is artistically lighted by incandescent lamps of 16 candle-power to 100 candle-power. Mr. Hartnell supplies current to 100 lamps on Stand 79, and to a few others. He has also one of his small dynamos running, bolted to the end, and driven by a 4 horse-power Stockport gas engine. This was originally designed and supplied as a 30 lighter for Algiers, but as a matter of fact it is driving a load equal to 45 lamps of 16 candle-power each. It runs exceptionally well, and has given no trouble. Two of this type were supplied some 18 months ago for private house-lighting near Belfast, and have not yet required any repairs or renewals whatever.



Hartnell's Patent Distributing Switchboard.



Hartnell's Wrought-iron Dynamo.

THE SANITARY ASPECTS OF ELECTRIC LIGHTING.*

BY W. H. PREECE, F.R.S.

The chief tendency of modern legislation in our British Parliament is to improve the environments of the human frame, so that we may live, and move, and have our being with greater health to the individual, and greater prosperity to the nation. The cleanliness of dwellings, the drainage of towns, the removal of filth, the suppression of nuisance, have not only been specified but the inspection of the means to effect these objects and of their results are defined and insisted upon by Acts of Parliament. People often speak disrespectfully of our grandmotherly Government; but at least in this region of domestic legislation, the control it has exercised over the food we eat, the water we drink, the air we breathe, is of a true parental order, and deserves our unreserved admiration and respect. The Home Office and the Local Government Board act the part of a wise and economic head of the house to the nation, while each commuuity has its own Local Board of Authority to carry out hygienic provisions, to enforce sanitary principles, to prevent infection, to stamp out disease, to sweeten labour, and to prolong life.

I contemplated at one time submitting an historical summary of these features of sanitary legislat ion during the present generation; but not only would the task be very onerous, but it would be

* A lecture delivered on August 26th to the Congress at Brighton of the Sanitary Institute.

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so lengthy that I should have very little time left to discuss the question set before me—the sanitary aspects of electric lighting.

The propositions that I propose to submit and to demonstrate to you are these :—

1. That electricity and light being analogous forms of energy, the former is naturally the proper source of artificial illumination.

2. That all other sources of artificial illumination being dependent on the absorption of oxygen, and resulting in the vitiation of air-are injurious to health.

3. That the same authority which regulates the sanitation of our dwellings and the supply of our food, should also control the purity of the air we breathe, and of the light we work by.

Light, however it be produced artificially, is simply the equivalent of work that has been done elsewhere. Whether it be by the combustion of tallow or oil, by the burning of coal or of gas, by the glowing of a fine wire, or the formation of the brilliant arc, energy has been expended somewhere, to be transferred and reproduced in some other place in the form of light. The great principle of the conservation of energy teaches us that the amount of energy in the universe is a fixed quantity, that it can be neither created nor destroyed, that it can only be transferred, and that any expenditure of energy—work done—anywhere is the equivalent of energy utilised somewhere else. The rate at which this energy is expended is called *power*, and the amount of power which we foolishly call a *horse-power*, and which we roughly imagine to be equivalent to the power exerted by a horse in drawing a load along a road, is competent to produce an amount of light which is very simply measured. Our standard of light is the light given by a No. 6 sperm candle, burning 120 grains per hour. Now the energy of one horse-power constantly expended will give by the aid of

Tallow	the light of	6	candles.
Sperm.....	,,	8·7	,,
Oil	,,	9	,,
Gas	,,	13	,,
Electric current—Glow ...	,,	248	,,
,, Arc	,,	1,492	,,

The results to the air of these different modes of producing artificial illumination are well shown by the following table :—

Products of Combustion in developing 100 candles per hour.

Illuminant.	Quantity consumed.	Carbonic acid produced.	Water vapour.	Heat.
	lbs.	Cub. ft.	lbs.	Calories.
Tallow	2·2	51·2	2·3	9,700
Sperm	1·7	41·3	2·0	7,960
Oil	1·3	33·6	1·8	7,200
Gas	56 cub. ft.	40·3	2·5	12,150
Electricity.....	(Coal) 2·2 lbs.	0	0	257

Thus we see how very much more efficient electricity is than any other agent for the production of light.

The tendency of the teaching of the present day is to show that the transmission of light waves and of electrical undulations is of the same character and at the same speed. Clerk Maxwell by theory, and Hertz by experiment, have placed this beyond doubt. A current of electricity passing through a fine filament, first raises its temperature, and then as the current is increased in strength, it glows brighter and brighter until finally it is disintegrated and dissipated with great brilliance, and the light disappears. There has been no chemical consumption of material. The passage of the current has resulted in light, and light seems to have been the natural sequence of the flow of electricity. Energy has, however, been developed somewhere. There is a boiler for the production of steam, an engine for the application of power, a dynamo for the formation of electric current.

Gas has to be extracted from coal, purified in gasworks, distributed through pipes, and chemically combined with the oxygen of the air in jets or burners. The simple candle, however, is its own gasworks. We simply apply a match and the flame itself becomes boiler, engine, and light emitter combined. In all cases, therefore, we have to consider—(*a*) the source of energy ; (*b*) the distribution of energy ; (*c*) the utilisation of energy as light.

The sources of energy at our disposal are—Wind, water, coal (steam), gas, and mineral oil. The inconstancy of the wind in our climate renders it inapplicable for the steady and constant supply of power required for artificial illumination.

Water, on the other hand, is an unfailing source of power in some countries, but the quantity required to produce even small effects is opposed to its use anywhere but in mountainous or hilly districts where it is abundant. It requires a quarter of a ton of water falling one foot *per second* to produce one horse-power, or falling ten feet to produce ten horse-power. If we wish to maintain ten ordinary electric glow lamps alight for five hours with a fall of ten feet, we should require 100 tons of water per hour, or 500 tons altogether. At Keswick, in Cumberland, a central station has been established, which is worked by a fall of twenty feet of the water of the river Greta, generating fifty horse-power by means of a turbine. At Portrush, in Ireland, a fall of twenty-six feet generates currents that work a tramway to the Giant's Causeway. Many private houses in Scotland are so lighted. There are innumerable places in the United Kingdom where this power is being allowed to run to waste. The non-utilisation is due probably to ignorance, and ignorance as much as indifference is the great obstruction which all new industries have to overcome, even when practicability and economy are almost self-evident. The power of running streams and of the tides is used in some countries for grinding corn, but the power utilisable is small, and no practical means have yet been introduced to employ them for small installations of electric lighting, though busy minds are actively engaged on this neglected field.

Steam, and therefore coal, becomes in all comparatively flat countries the principal source of power, while, for small installations, gas and mineral oil are extremely convenient, cleanly, and economical suppliers of energy. Indeed, gas as a source of heat is coming more and more into use, and if a cheaper form of gas such as water-gas were distributed for fuel purposes—as it probably will in the future—it would solve the difficulty of the transit of coal, and prevent the possibility of that nuisance, the formation of smoke in the midst of shops and dwellings.

The power that is thus expended is employed in developing electrical energy. Motion is imparted to coils of copper wire in a field of magnetism, and a certain resistance has to be overcome when the lines of force in this field are cut by the wire ; the energy of motion is absorbed, it takes the form of electricity, and, as an electric current, it can be transmitted to a distance, and there utilised. The amount of energy which is found in the form of currents is that delivered by the belt of the engine to the dynamo, less a small amount wasted in friction and in heat in the metal of the dynamo ; but this is so small that it is a common thing now to obtain dynamos with an efficiency of 94 per cent., that is, 6 per cent. only of the power applied to it is lost as heat in the dynamo itself.

If a child has a skipping rope made of copper wire, and, with its face turned due north or south, it skipped, the rope would cut the lines of magnetic force of the earth in the proper direction, the rope would experience resistance, energy would be absorbed by the rope, and electric currents would be developed from hand to hand of the child. The child thus becomes an animated dynamo. The lines of force of the earth flowing north and south are cut twice in each revolution of the skipping rope, but alternately in opposite directions. Hence the currents generated are alternately flowing in opposite directions, and the child becomes an alternate-current dynamo. It is a very simple thing to straighten these currents and to make them flow continuously in the same direction, and to convert these alternate effects into continuous currents flowing in the same direction.

Now, all electric currents require an electromotive force, or a difference of electric pressure to drive them through the resistance of metallic conductors, in the same way that water and gas require pressure to drive them through pipes. This electromotive force in the case of the skipping rope is very minute, because the intensity of the earth's magnetic field is very small (it is only $\frac{1}{20000}$th of the field of an ordinary dynamo), the motion of the rope is comparatively slow, and there is only one cutting conductor. If we increase the number of conductors, their speed and the strength of the field, we can magnify the electric pressure to any amount.

All new ideas require new names to indicate them, and if they are new quantities capable of measurement, they require new units to compare them with numerically. Difference of electric pressure is called voltage, and the unit of comparison is a *volt*. The skipping rope developes only a very small fraction, about $\frac{1}{1000}$th of a volt. There are now dynamos at Deptford which will generate 10,000 volts, and a flash of lightning is the result of perhaps millions of volts. The human frame is very sensitive to voltage, 50 volts is scarcely perceptible, 100 volts give a distinct though slight shock, 500 volts are painful, and 1,000 volts might probably, under certain circumstances, kill a man, 10,000 volts, if effective through the whole frame would certainly destroy life. We have recently read of a deplorable attempt in the United States to utilise this power for the execution of criminals, an attempt surrounded with sickening horrors, the result of the ignorance that exists at present as to the effects of electricity on the human frame.

The unit of electric current by which measurements are made is called an *ampere*. If an ampere be circulated around a bar or ring of iron, it will magnetise it with a definite amount of magnetism dependent upon its dimensions and quality. If it be transmitted through a bath of nitrate of silver, it will deposit four grammes of silver per hour. If it be driven through a fine filament of car-

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bonised cotton 6 in. long, such as Edison and Swan use for their glow lamps, by an electromotive force of 100 volts, it will develop a brilliant light of 32-candle power.

The actual energy conveyed by the current is measured by the product of the volts and amperes, and this measures the rate at which energy is being transmitted or expended. The unit of measurement is called *the watt*, which is a much more scientific and accurate unit of power than the absurd horse-power that has become so rooted among our engineers. A man in pumping expends about 50 watts; in rowing a race he expends about 100; in running rapidly upstairs he expends 500 watts for a few seconds; a horse drawing a load on a level road expends about 500 watts. The so-called horse-power is 746 watts. An ordinary arc lamp consumes 500 watts, and an electric tramcar going at seven miles an hour on an average tramway, requires a mean power of about 3,000 watts.

Electrical energy is measured and paid for in 1,000 watts or in *kilowatts* delivered per hour. A kilowatt-hour is called the Board of Trade unit of electrical energy, and it is defined in all Provisional Orders confirmed by Act of Parliament, thus:—"The expression 'unit' shall mean the energy contained in a current of one thousand amperes flowing under an electromotive force of one volt during one hour." This Board of Trade unit has not yet received a name. I have proposed to call it a *Bot*, from the initial letters of the Board of Trade, but there is generally a very strong aversion to a new name, however much it may be wanted, and we have during the past few years had a plethora of new names in electrical science. One Board of Trade unit will keep an ordinary 10-candle power glow-lamp alight for 30 hours, or it will keep 30 of such lamps alight for one hour. In Newcastle this energy costs 4½d., in Liverpool 6d., in London 7½d., and in most other places 8d. Taking the cost at 6d., a 10 candle-power glow-lamp would cost one-fifth of a penny per hour, which is the cost of a 5ft. gas burner at 3s. 4d. per 1,000 cubic feet. There is thus very little difference between the price of gas and that of electricity.

The output of a dynamo is measured in watts, and, as the number of watts in ordinary dynamos is necessarily numerous, the *kilowatt*, or 1,000 watts, is the unit employed. Thus, a dynamo of 100 kilowatts developes energy equivalent to 134 horse-power, and as, for ordinary purposes, the ratio of the power utilised as electric current to the power indicated in the cylinders of the engine may be taken at 80 per cent., it will follow that it will require 160 horse-power to drive such a dynamo at full load. The relations between mechanical and electrical measurements are thus very simple and wonderfully accurate. 100 kilowatts, or 100,000 watts, deliver sufficient energy to illuminate 3,000 10 candle-power lamps, and one of the most difficult problems which the electrical engineer has to solve is to design the best and most economical method of distributing this energy over an extended area. If the distribution be confined to one big building, like the Pavilion in Brighton, or the Post Office in London, the solution is simple. If it be over a widely scattered district, like Croydon, Wimbledon, or the districts of the great vestries of London, the solution is complicated. Every district must be governed by its own conditions, and be controlled by its own environments.

There are several modes of distribution under high pressure or low pressure; by means of alternate currents or of continuous direct currents; by two wires or three wires or five wires. Then, again, the supply may be for light or motive power, for street lighting, or for private lighting. If it be by high pressure, say of over 300 volts, then, as such pressures cannot be admitted into our houses, there must be a reduction of this pressure to the safe and ordinary 100 or 50 volts by means of alternating transformers or of secondary batteries. The ruling guide is of course economy. A certain number of kilowatts are generated in the central station, at a price per hour that is easily obtained from the coal bills, the stores list, and the wages sheet. A certain proportion of this energy is delivered to the consumers, and paid for by them by meter or by contract. A certain proportion is lost: wasted as heat in the apparatus and conductors. What is the proportion between the energy paid for, and that generated by the central station? What is, in fact, the efficiency of the system? It is difficult in the present tentative and youthful condition of the industry to obtain a true answer. Most central stations are in their pioneer condition. I have, however, examined the figures of certain well-known systems, from which I gather that we may estimate the following efficiencies as fairly practical:—

	Efficiency.
Low pressure—	
Continuous direct current	90 per cent.
High pressure—	
Alternate current	60 ,,
Direct-current battery	50 ,,

In fact, one Company—the St. James and Pall-mall—working on the low-pressure system, have on the first half-year of 1890 secured a return of 94·3 per cent. on the energy delivered, while another Company, working on the high-pressure battery system, secured only 29 per cent. In January of this year, at the Kensington Court Central Station, working at low pressure, 25,893 bots were registered and paid for, as against 28,291 generated and distributed, representing an efficiency of 92 per cent. At Dacre-street, Westminster, also working at low pressure, in the quarter ended 24th June—the summer and lowest quarter—the efficiency was 84·4 per cent. At the House of Commons the efficiency has been 89·8 per cent. A simple way of looking at the matter is to find out the coal consumed per bot paid for by the consumer. It comes out—

Low pressure	9lb.
High pressure	17lb.

It is worth noting that it would require 38lb. of coal distilled in the gas works to produce the same light by means of the ordinary fish-tail burner.

The misfortune is, that the low-pressure system is applicable only to confined and restricted districts. It involves the use of such heavy conductors, that as the district increases in extent, the weight of copper required varies as the third power of the radius of the area served. While with the high-pressure system the weight of copper required diminishes with the pressure used. It must, however, be recollected that the use of high pressure involves the use of very highly insulated conductors, and therefore what is saved in copper may be expended in insulation. The question that decides the economic use of high or low pressure is the distance or length of mains and feeders, when the difference between 17lb. and 9lb. of coal (or a penny per bot) is swallowed up in interest on capital and waste of energy in the heavy conductors required by the low-pressure system.

The consequence is, that while compact areas, covered by a radius of half a mile, are best served on the low-pressure system, those supplied beyond a radius of one mile can be served economically only on the high-pressure system, while the intermediate range is to be considered simply with reference to its own requirements and its own conditions, such as the supply of water and of coal, the convenience of water and railway carriage, the value of land, the demand of residential districts, and of manufacturing and business quarters. Each district must therefore be dealt with on its own merits. In London at the present moment several different systems are being used or installed for very similar districts. Thus we have the alternate-current transformer system at Brompton, St. Martin's, St. Giles, and the various portions served by the London Electric Supply Association, the high-pressure battery system in Chelsea, the low-pressure system aided by secondary batteries to regulate pressure and to maintain the supply of energy during the small hours of the morning, or when breakdown or cases of emergency arise, in Kensington, Westminster, St. James's, Notting Hill, and St. Pancras. The proper system to be used is therefore still in a tentative condition.

The great question that divides the merits of the high and low-pressure is that of safety to person. Grossly exaggerated accounts of accidents in America have seriously prejudiced the public mind against the high-pressure system. If people only saw for themselves the conditions that surround the distribution of electricity in the United States, they would not be surprised at the accidents that have happened—they would wonder at their being so few. Poles are frequently carried down the principal streets of the towns carrying open telegraph, telephone, fire signal, and electric light wires, all together on the same support, without any particular rules or regulations. A lineman who ascends a pole to attend to a telephone wire is very apt to touch suddenly an electric light conductor. He receives a shock, and is thrown down perhaps on the ground and killed, or perhaps among the other wires, where he may be probably burnt or otherwise injured.

Such things are impossible in England. Mains and conductors must, by legislation, be placed underground in all towns; but where they are for local reasons placed overground, they are subjected to carefully prepared rules and regulations, and to watchful and constant inspection. A high-pressure conductor is certainly dangerous if it were handled; but it should never, under any circumstances, be so placed as to be in a position to be touched by anyone but the skilled technical men who have the charge of its maintenance. There is no case on record of anyone being hurt on a well-designed underground system.

The great hygienic advantage of the electric light when illuminating our dwellings and our workshops is not that it purifies the air, but that it prevents the air from being vitiated by the introduction into it of the products of combustion, such as carbonic acid, carbonic oxide, sulphurous acid, &c., it prevents the air from being weakened by the abstraction of oxygen, and it prevents it from having its temperature raised by undue radiation, and by throwing into it heated gases.

While legislation and the greatest possible stringent regulations have been drawn up to prevent the adulteration of food and the poisoning of water, scarcely any attention has been devoted to the prevention of the admission of noxious gases and poisonous vapours into the air of our habitations. Carbonic oxide is a poison of the

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deadliest character, and gas jets are freely used which deliver copious discharges of this dangerous gas into the atmosphere of our rooms. If we were consistent in our legislation, we ought to forbid the use of any burner which thus poisons the air. A man at rest exhales ·00424 cubic feet of carbonic acid gas (CO_2) and ·1189 cubic feet of air per pound weight per hour, while a gas jet burning 5 cubic feet of coal gas exhales 4 cubic feet of CO_2. The maximum proportion of CO_2 to air consistent with health is 6 volumes in 10,000; 10 volumes affect the heart, and 30 volumes produce headaches. Rheumatism, bronchitis and other ailments proceed from higher proportions. In fact, 5 cubic feet of gas requires 8,000 cubic feet of pure air per hour to maintain it healthy. The electric light requires no such provision.

That the electric light is a powerful element of health is evidenced by the fact that those who use it not only feel all the better for its introduction, but their appetite increases, and their sleep improves, and the visits of the doctor are reduced in frequency. Workpeople work all the better, and absences from illness are far less frequent. In the Savings Bank in Queen Victoria-street, London, where 1,200 persons were employed, the absences from illness were so far reduced that the extra labour gained paid for the electric light. In Liverpool and many other places the same result has been observed.

The influence of artificial light on the eyes has a very important sanitary bearing. Why is it that there is so much shortsightedness in the present day? Is it due to our mode of producing light? Some assert that the injury to the eyes is due to the heat rays and not the light rays. If that be so, the electric light must be much less injurious than any other. On the other hand, no one can have experimented with arc lamps without having had his retina painfully affected, which leads one to think that the ultra-violet rays have some influence. No one has, however, ever complained of the influence of a steady glow-lamp upon the eyes, and it is possible to read and to write for many hours by such a light without experiencing the least fatigue.

The electric current is not altogether free from being a cause of fire, and though its use is by no means very general, still it is used sufficiently to make itself felt as an element of danger in this respect. The following table shows the number of fires in London which can be traced to the different methods of lighting:—

	1887.	1888.	1889.	Total.
Lamps	245	205	257	707
Gas	188	197	209	594
Candles.....	142	113	136	391
Electricity	0	1	2	3

The progress of the electric light in our homes has been much more rapid in England than in any other country, but its employment for street lighting, for shops and manufactories, has been infinitely more rapid and extensive in the United States than with us. In America the growth has been enormous. There are now 250,000 arc lamps, illuminating the public streets and shops, and 3,000,000 glow lamps in dwellings, stores, and workshops.

The following table shows the development of the Berlin Central Stations:—

Station.	Effective horse-power.						
	1884.	1885.	1886.	1887.	1888.	1889.	When completed.
Friederickstrasse..	300	300	300	300	300	300	300
Markgrafenstrasse	...	1,000	1,000	1,000	2,400	2,400	3,100
Mauerstrasse	...	...	500	1,250	1,250	2,950	4,950
Spaudauerstrasse..	...	...	...	...	...	2,000	4,000
Schiffbauerdamm.	...	...	...	...	...	1,000	6,000
Total	300	1,300	1,800	2,550	3,950	8,650	18,350
16 c.p. lamps, or equivalent	2,500	4,600	13,229	24,660	34,750	...	...
Kilometres of cable	...	8	10	15	25	75	...

The progress in England has been very much checked by inordinate speculation and by terrible failures in some of the earlier work done. There is something very captivating in the practical applications of electricity, and something romantic in its mystery. The neophyte has rushed into it with remarkable fervour, and the lessons of failure have in consequence been very severe. The users of the light have also been paying heavily for the education and experience of amateur tradesmen and inexperienced contractors, and have neglected to avail themselves of the professional services of the experienced electrical engineer. People who would not build houses without the architect, nor construct bridges without the engineer, nor make their wills without the lawyer, rush wildly into the use of electricity without any professional assistance, where, above all things, experience and knowledge are essential to prevent disaster and disappointment. Large installations have been completed without specifications to guide the contractor, and without inspection to see that the work has been properly done. The user has paid violently for his temerity, and fires and accidents have been the result. The heavy price for wiring a rented house, and the expensive character of the fittings proposed, have deterred many from adopting the light, even when it is within their reach. Highly insulated wire is unfortunately expensive. All cheap wires are nasty and dangerous. There is nothing that becomes the electric light better than simplicity, and its effect is frequently marred by elaborate brass work. It possesses also most active and widespread opponents, both in oil and gas—opponents who have benefited by its introduction, and who are not slow to profit by its advance. The improvements in gas and oil lamps are as marked as the advancements in electric light, and as means of artificial illumination alone—that is as far as light-giving power is concerned—there is little choice between the three; but oil and gas cannot lose those elements of discomfort and ill-health which differentiate them from the cool and pure glow lamp.

A very important question arises for discussion. Legislation has slipped in to place the virtual control of the supply of electrical energy in the hands of the Local Authority of the district to be served. Is this supply to be the result of the capital of private enterprise, or is it to be effected by raising money on the security of the rates? It is argued that the supply of electricity being a purely commercial undertaking, it should therefore be carried out by a limited liability company. The Acts of 1882 and 1888 do not encourage monopoly, but rather court competition, and competition attracts capital. Competition properly regulated and controlled secures economy in supply, and certainly enforces economy in working, while it encourages improvements, and induces perfection of apparatus and novelty in processes. These arguments are plausible, but are easily refuted by those who desire to uphold vested monopolies. Direct competition always means ultimately enhanced cost to the public, for the same public has to pay for double plant, and each competitor only gets half revenue.

The supply of light is in precisely the same category as the supply of water or the supply of gas, and the days have certainly passed when the public will tamely submit to the transference of their right to such vested interests as those of water or gas companies. It is very easy to argue *pro* or *con.* on each side. The Local Authority has to regard the security of traffic, the safety of person, the repression of crime, and the proper supervision of the premises of its ratepayers. It is the custodian of the public interests. It has to control the health, cleanliness, comfort, and beneficial sanitation of its habitable dwellings. It, therefore, must secure the best light, and if it can do this, and at the same time relieve the rates which are generally creeping up to dangerous dimensions, then its action would be wise and economical. But it would be entering into commercial rivalry with an active competitor—the gas companies; and its commercial control by such a shifting authority as a committee of a Town Council or of a Local Board, subject to the changes of political warfare—to the vagaries of press dictation, and to the fear of November elections—is a very doubtful proceeding. On the other hand, in many instances, such bodies have successfully dealt with the water question, the tramways, and even with the gas. In fact, one-third of the gas capital (21 millions) in this country is in the hands of 173 Local Authorities, and more than half a million of profits go to the reduction of rates.

Bradford has already grappled with the question. It has established a central station for the supply of the electric light. Brighton, St. Pancras, and Bristol are doing the same, and many other places are following suit. They are shying at the probability of handing over their districts to a speculative company, with a virtual, though not a legal monopoly, to supply electrical energy for 42 years. Many corporations contemplate a middle course. They have obtained the power for themselves, but they have farmed for shorter terms the right of supply to private enterprise, which can do what they are afraid to do, viz.—speculate and experiment. The Board of Trade has sanctioned and facilitated such a transfer of statutory rights.

It is surprising that gas administrations in England have not been more enterprising in developing electric lighting. In Vienna, Rome, and Stockholm the gas companies have established central stations, and the progress of the industry in those cities is very great. The proper function of gas is to supply heat, not light; and as a source of power it has a future more brilliant than its past. If it could be supplied as fuel, it would remove the troubles of coal transit and storage, of ash and dust removal, of smoke and of stoking. It has even been shown that it is cheaper to convert coal into gas on the spot, and to use the gas as the source of power, than to apply the coal direct for the production of steam in boilers.

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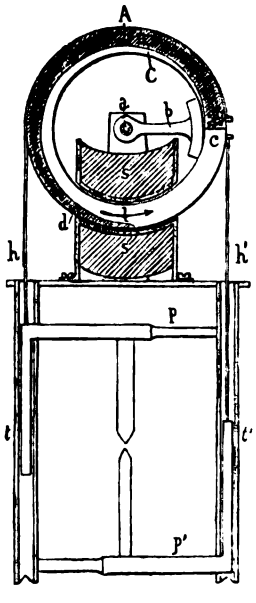
The waste of energy in the use of coal is enormous. The energy contained in one pound of coal if burnt in one hour is theoretically sufficient to supply 5·6 horse-power for that hour. The best practical result yet obtained by the steam engine is scarcely one horse-power. The electric light is unquestionably the light of the future. Its use is advancing with leaps and bounds. Not only is it naturally the proper source of light, but economically it must eventually supplant its rivals. When electrical energy is generally distributed through our towns, and its supply is continuous, and properly controlled, so that it is always within the reach of all, and when means can be devised to wire up houses as cheaply as they are now fitted for gas, everyone will take it, not alone for its beauty, but because it is, above all, a source of health and comfort.

THE ZWEIFEL ARC LAMP.

This lamp, which was exhibited at the Paris Exhibition of 1889, is of very simple construction. It consists of a ring of iron or copper, moving inside a solenoid, working the carbon holders by means of two small chains, and thus striking the arc and supplying the feed.

The ring A is composed necessarily partly of iron, the section of which increases from d to e, and is carried by the arm b; the remaining portion of the ring consists of brass, the two metals being so proportioned that perfect equilibrium is obtained between them about the axis a. To the ring are attached two small chains, $h\,h'$, from which are suspended the carbon holders $p\,p'$, which are guided by a special arrangement inside the tubes t and t'. The lower carbon holder p' is heavier than the



The Zweifel Arc Lamp.

upper carbon holder p, and consequently tends to separate the carbons, and bring the ring into its extreme position as shown in the diagram. When a current passes through the solenoid, it tends on the other hand by reason of its action on the iron of the ring to move it in the direction of the arrow l, and to bring the carbons together. The solenoid is a fine wire coil, and is connected as a shunt to the two carbon holders. It governs, therefore, the potential difference between the two carbons, or, in other words, the distance of the two carbons from each other. By keeping this distance constant we obtain a steady light, the intensity of which may be regulated by means of a suitable rheostat.

The mode of working is as follows:—When no current passes through the apparatus, the extra weight of the lower carbon p', acting on the small chain h', causes the ring to turn from left to right, and to bring it into the extreme position represented in the diagram, and consequently to separate the carbons; but when the lamp is placed in connection with a source of electricity, the current will be unable to pass through the carbons, which are separated, but will go through the solenoid, and the latter will act energetically on the iron portion of the ring. This ring then moves from right to left, the upper carbon falls and the lower one rises, this movement continuing until the carbons touch. When the carbons are in contact the whole current passes through them. The coil, no longer receiving any current, will exert no force upon the ring. The extra weight of p' acting on the ring will produce a movement in the opposite direction, the two carbons being drawn apart, and the arc struck. As the arc lengthens the current encounters more and more resistance in its passage through the carbons, and more current will pass through the solenoid, which thus becomes more powerful as the arc becomes longer.

The two opposing forces in this case are—

(1) The attraction due to the coil, which increases with the length of the arc.

(2) The difference in the weights of the carbon-holders.

Equilibrium exists when the attractive force is equal to the force due to the difference in the weights of the carbon-holders. The attractive force being a function of the length of the arc, it is easy to understand that one has only to regulate the difference in weight in order that the solenoid may maintain any desired length of arc. It is only necessary that the ratio of the attractive force to the difference between the weights of the carbon holders should be the same for all positions of the ring for the lamp to constantly maintain the same distance between the carbons.

The above arrangement is usually employed for lamps run on incandescent light circuits; for use in series working a lamp with a differential action is used. It is said that the light given by this lamp is very steady, the feeding being very rapid and continuous. The lamps may be worked either singly or in pairs on incandescent light circuits, working with a resistance which only absorbs, it is stated, from 15 to 20 per cent. of the energy supplied to the lamp, whilst most lamps at present in use waste in the resistance about 40 per cent. of the total energy supplied. Amongst the advantages that this lamp possesses are a fixed focus, compactness, and freedom from complicated mechanism.

THE NEW BOARD OF TRADE REGULATIONS.

The following are the Regulations and Conditions for securing the safety of the public, and for ensuring a proper and sufficient supply of electrical energy, made by the Board of Trade under the provisions of the Electric Lighting Acts, 1882 and 1888, and of the Notting Hill Electric Lighting Order, 1889:—

Definitions.

In the following regulations:—

The expression "the order" means the Notting Hill Electric Lighting Order, 1889.

The expression "the undertakers" means the undertakers for the purpose of the order.

The expression "consumer" means any body or person supplied or entitled to be supplied with energy by the undertakers.

The expression "consumer's terminals" means the ends of the electric lines situate upon any consumer's premises and belonging to him at which the supply of energy is delivered from the service lines.

The expression "consumer's wires" means any electric lines on a consumer's premises which are connected with the service lines of the undertakers at the consumer's terminals.

The expression "aerial conductor" means any conductor which is placed above ground and in the open air.

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and the earth; pressure on any alternating-current system being taken to be the equivalent of pressure on a continuous-current system when it produces an equal heating effect if applied to the ends of a thin stretched wire or carbon filament; and

(*a*) Where the conditions of the supply are such that the pressure cannot at any time exceed 300 volts, if continuous, or the equivalent of 150 volts, if alternating, the supply shall be deemed a low pressure supply;

(*b*) Where the conditions of the supply are such that the pressure may exceed the limits of a low-pressure supply, but cannot exceed 3,000 volts, or the equivalent of 3,000 volts, whether continuous or alternating, the supply shall be deemed a high-pressure supply;

(*c*) Where the conditions of the supply are such that the pressure may on either system exceed 3,000 volts or the equivalent of 3,000 volts, the supply shall be deemed an extra high-pressure supply.

Mains, service lines, and other conductors and apparatus are referred to as low-pressure, high-pressure, and extra high-pressure mains, &c., according to the conditions of the supply delivered through the same or particular portions thereof.

Provided that in the case of conductors laid under the surface of the ground in conduits, in accordance with these regulations, and being the property or under the sole charge of the undertakers, low pressure conductor shall mean any conductor in which the pressure between that conductor and the earth cannot at any time if continuous exceed 300 volts, or if alternating, 150 volts, or between that conductor and any other conductor laid in the same conduit cannot at any time if continuous exceed 500 volts, or if alternating, 250 volts.

When any casing, support for conductors, conducting wire, or other metallic body is required to be efficiently connected to earth, it shall be deemed to be so connected when it is connected to metallic mains for water supply outside of buildings, or, where these are not available, to a

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mass of metal having a total surface of at least four square feet, buried to a depth of at least three feet in moist earth, by means of a conductor possessing a mechanical strength, and offering a passage to electrical discharges, equal to that of a strand of seven No. 16 galvanised iron wires.

The expression "daily penalty" means a penalty for each day on which any offence is continued after conviction thereof.

All other expressions to which meanings are assigned in the Order, or principal Act, have the same respective meanings in these regulations.

I.—Regulations as to Safety.

General.

1. *Low-Pressure Supply to Consumers.*—Save as hereinafter provided, the supply of energy delivered to the consumer's terminals shall be a low-pressure supply.

2. *Limitations of High-Pressure Supply.*—A high-pressure supply shall not be delivered to any consumer's terminals, except for special purposes, and with the approval of the Board of Trade on the joint application of the consumer and the undertakers, and subject to such further regulations as the Board of Trade may from time to time prescribe. But a high-pressure supply may be given to distributing or converting stations or points, or to distributing mains, in accordance with the following regulations.

3. *Limitations of Extra High-Pressure Supply.*—An extra high-pressure supply shall not be given except to distributing stations or other premises in the sole occupation of the undertakers, and with the written consent of the Board of Trade, and subject to such regulations and conditions as the Board may prescribe.

Mains and other Conductors.

4. *Maximum Current in Conductors.*—The maximum working current shall not be sufficient to raise the temperature of the conductors or any parts thereof to such an extent as to materially alter the physical condition or specific resistance of the insulating covering, if any, or in any case to raise such temperature to a greater extent than 30° of Fahrenheit's thermometer; and efficient automatic means shall be provided which will render it impossible for this maximum working current by any accident to exceed such limit to the extent of 50 per centum, even for short intervals of time; and special care shall be taken that the cross sectional area and conductivity at joints are sufficient to avoid local heating, and that the joints are protected against corrosion.

5. *Lightning Protectors.*—Where any portions of any conductors are exposed in such a position as to be liable to be affected by lightning, they shall be efficiently protected against accident by appliances of such pattern and construction as may from time to time be approved by the Board of Trade.

6. *High-Pressure Conductors Laid Above Gound.*—Where any high-pressure conductors, other than aerial conductors, are placed above the surface of the ground, they shall be completely enclosed in brickwork, masonry, or cement concrete, or in strong metal casing efficiently connected to earth.

7. *High-Pressure Conductors Laid in Subways, &c.*—Where any high-pressure conductors are laid in subways, or in the same conduits with any low-pressure conductors, they shall be completely enclosed in strong metal casing efficiently connected to earth.

8. *High and Low Pressure Conductors Laid in Proximity.*—Where any high-pressure conductor is laid within a less distance than 18in. for any low-pressure conductor, or from the surface of the ground, or where any low-pressure conductor is laid within the above-mentioned distance from any previously laid high-pressure conductor, efficient means shall be taken to render it impossible that the low-pressure conductor or the surface of the ground shall become electrically charged by any leakage from or defect in the high-pressure conductor.

9. *Continuous Insulation.*—Every high-pressure conductor shall be continuously insulated with a durable and efficient material, which shall be protected on the outside against injury or removal by abrasion, and every such conductor shall be tested for insulation after having been laid in position, and before any joints for service lines are made. The insulation resistance under these conditions shall not be less in any section of the conductor than at the rate of 100,000 ohms per mile for every volt of pressure of the supply under a testing pressure of at least 100 volts, and the undertakers shall duly record the results of the tests of each conductor or section of a conductor, and at all times permit an electric inspector to examine and take copies of such record.

10. *Minimum Insulation Resistance Allowable; Indicator of Leakage.*—The insulation resistance of any complete circuit used for high-pressure supply, including all devices for producing, consuming, or measuring energy, connected to such circuit, shall be such that should any part of the circuit be put to earth through a resistance of 2,000 ohms, the leakage current shall not exceed 0·04 ampere in the case of continuous currents, or 0·02 ampere in the case of alternating currents. Every such circuit shall be fitted with an instrument of such pattern and construction as may from time to time be approved by the Board of Trade, which shall immediately indicate any defect which may at any time occur in the insulation resistance of either conductor.

Every such circuit shall be tested for insulation at least once in every week, and the undertakers shall duly record the results of such testings, and at all times permit an electric inspector to examine and take copies of such records.

11. *Precautions against Sparking with High Pressure Alternating Current Mains.*—In the case of a high-pressure supply on any alternating-current system, where separately insulated conductors are laid in the same conduit, or pass through the same boxes, precautions shall be taken against the discharge of electric sparks between the insulating covering of oppositely charged conductors, by providing a sufficient connection of a conducting nature from one covering to the other throughout.

Conduits.

12. *Conduits to be Durable and Strong.*—All conduits used as receptacles for conductors shall be constructed of durable material, and of ample strength to resist any pressure due to heavy traffic or other forces to which they may be expected to be subjected.

13. *Conduits to be Kept Free from Water.*—Where the conductors in any conduit are not continuously insulated, adequate precautions shall be taken to insure that no accumulation of water shall take place in any part sufficient to raise the level of the water into contact with the conductors.

14. *Conduits to be Kept Free from Gas.*—All conduits for conductors constructed in streets in which gas mains are also laid, shall be efficiently protected against an accumulation of gas.

15. *Street Boxes to be Kept Free from Gas and Water and Secured.*—All street boxes shall be efficiently protected against an accumulation of gas or water, and their covers so secured that they cannot be opened except by means of a special appliance.

Converting Stations.

16. *Converting Stations.*—Converting stations, or points in a system of distribution to which a high-pressure supply is given from generating stations, and from which a low-pressure supply is given to one or more consumers, and which are not on the consumer's premises, shall be established in suitable places, which are in the sole occupation and charge of the undertakers.

17. *Precautions against Contact.*—In every case where the supply is transformed at a converting station as described in the preceding regulation, some means or apparatus approved by the Board of Trade shall be provided which shall render it impossible that the low-pressure distributing mains shall be at any time charged to a dangerous difference of potential from the earth, owing to any accidental contact with, or leakage from, the high-pressure system either within or without the converting station.

Consumers' Premises.

18. *Transformers and High-Pressure Apparatus to be Enclosed in Metal.*—Where the general supply of energy is a high-pressure supply, and transforming apparatus is installed on the consumer's premises, connected to the distributing mains by high-pressure service lines, and to the consumer's terminals by low-pressure service lines, the whole of the high-pressure service lines, conductors, and apparatus, including the transforming apparatus itself, so far as they shall be on the consumer's premises, shall be completely enclosed in solid walls, or in strong metal casing efficiently connected to earth, and securely fastened throughout.

19. *Precautions against Contact.*—In every case where any transforming apparatus is installed on the consumer's premises, as described in the preceding regulation, some means or apparatus approved by the Board of Trade shall be provided, which shall render it impossible that the low-pressure service lines and consumer's wires shall be at any time charged to a dangerous difference of potential from the earth, owing to any accidental contact with, or leakage from, the high-pressure system either within or without the transformer.

20. *Low-Pressure Apparatus to be Insulated.*—All terminals, low-pressure service lines, or other apparatus, between the transforming apparatus or other source of supply and the consumer's terminals, so far as they shall be on the consumer's premises, shall be completely enclosed in insulating cases or coated with insulating material in such a manner that no part of them can be touched by any person without the removal of such case or coating, and, wherever exposed, shall be efficiently protected against injury to the insulation.

21. *Responsibility of Undertakers for their Lines, &c., on Consumer's Premises.*—The undertakers shall be responsible for all electric lines, fittings, and apparatus belonging to them, or under their control, which may be upon the consumer's premises being maintained in a safe condition, and in all respects fit for supplying energy.

22. *Fire Risks.*—In delivering the energy to the consumer's terminals, the undertakers shall exercise all due precautions so as to avoid risk of causing fire on the premises.

23. *Testing Consumer's Wires for Leakage by Undertakers.*—If the undertakers are reasonably satisfied, after making all proper examination by testing or otherwise, that a connection with the earth exists at some part of a circuit, of such resistance as to be a source of danger, and that such connection does not exist at any part of the circuit belonging to the undertakers; then, and in such case, any officer of the undertakers, and duly authorised by them in writing, may, for the purpose of discovering whether such connection with the earth exists at any part of a circuit within, or upon, any consumer's premises, at all reasonable times, after giving one hour's notice of his intention to do so, enter any such premises and disconnect the consumer's wires from the service lines, and may require the consumer to permit him to inspect and test the wires and fittings belonging to the consumer and forming part of the circuit.

24. *Supply to be Discontinued.*—If on such testing the officer discovers that a connection exists between the consumer's wires and the earth, and that such connection has an electrical resistance not exceeding 5,000 ohms, or if the consumer does not give all due facilities for such inspection and testing, the undertakers shall forthwith discontinue the supply of energy to the premises in question, giving immediate notice of such discontinuance to the consumer, and shall not recommence such supply until they are reasonably satisfied that such connection with the earth has been removed.

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Provided that in cases where the maximum power taken by any consumer exceeds 25,000 watts, the consumer's wires may be divided for the purposes of this testing into separate circuits, the insulation resistance of each of which shall exceed 5,000 ohms.

25. *Appeal to Electric Inspector.*—If any consumer is dissatisfied with the action of the undertakers either in discontinuing or in not recommencing the supply of energy to his premises, the wires and fittings of such consumer may, on his application, and on payment of the prescribed fee, be tested for the existence of connection with the earth by an electric inspector, or if no electric inspector has been appointed, by a person appointed by the Board of Trade.

This regulation shall be indorsed on every notice given under the provisions of the last preceding regulation.

Regulations as to Aerial Conductors where Erected with Necessary Consents.

26. *Height from Ground and Distance from Buildings, &c.*—An aerial conductor shall not in any part thereof be at a less height from the ground than 20ft., or where it crosses a street 35ft., or within 7ft. of any building or erection other than a support for the conductor, except where brought into a building for the purpose of supply.

27. *Service Lines from Aerial Conductors.*—Service lines from aerial conductors shall be led as directly as possible to insulators firmly attached so some portion of the consumer's premises which is not accessible to any person without the use of a ladder or other special appliance, and from this point of attachment to the consumer's terminals they shall be enclosed and protected in accordance with the preceding regulations as to service lines on the consumer's premises.

28. *Maximum Intervals between Supports.*—Every aerial conductor shall be attached to supports at intervals not exceeding 200ft. where the direction of the conductor is straight, or 150ft. where this direction is curved, or where the conductor makes a horizontal angle at the point of support.

29. *Supports, Construction and Erection of.*—Every support of aerial conductors shall be of a durable material, and properly stayed against forces due to wind pressure, change of direction of the conductors, or unequal lengths of span, and the conductors and suspending wires (if any) shall be securely attached to insulators fixed to the supports. The factor of safety for the conductors and suspending wires shall be at least six, and for all other parts of the structure at least twelve, taking the maximum possible wind pressure at 50 pounds per square foot. No addition need be made for a possible accumulation of snow.

30. *Connection of Support to Earth.*—Every support, if of metal, shall be efficiently connected to earth, and if of wood or other non-conducting material, shall be protected by a lightning conductor fastened to the support along its entire length, and projecting above the support to a height of at least six inches, such lightning conductor being efficiently connected to earth.

31. *Angle of Crossing Thoroughfares.*—Where any aerial conductor crosses a street, the angle between such conductor and the direction of the street at the place of such crossing, shall not be less than 60 degrees, and the spans shall be as short as possible.

32. *Crossing Other Wires.*—Where any aerial conductor belonging to the undertakers is erected so as to cross any other aerial conductor or any suspended wire used for purposes other than the supply of energy, precautions shall be taken by the undertakers against the possibility of their conductor coming into contact with such other conductor or wire, or of such other conductor or wire coming into contact with their conductor by breakage or otherwise.

33. *High-Pressure Conductors to be Insulated.*—Every high-pressure aerial conductor shall be continuously insulated with a durable and efficient material to be approved by the Board of Trade, to a thickness of not less than one-tenth part of an inch; and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation shall not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000. This insulation shall be further efficiently protected on the outside against injury or removal by abrasion. If this protection be wholly or partly metallic it shall be efficiently connected to earth.

34. *Specification of Insulation.*—The material used for insulating any high-pressure aerial conductor shall be such as will not be liable to injurious change of physical structure or condition when exposed to any temperature between the limits of 0° and 150° Fahr., or to contact with the ordinary atmosphere of towns or manufacturing districts.

35. *Suspension of Conductors.*—Every aerial high-pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspending wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspending wires, where attached to supports, shall be in contact only with material of highly insulating quality, and shall be so attached and guarded, that in case they break away it shall not be possible for them to fall away clear of the support.

36. *Undertakers Responsible for Supports.*—The undertakers shall be responsible for the efficiency of every support to which their aerial conductors are attached, and every such support shall be marked to indicate the ownership of the conductor.

37. *Maintenance.*—Every aerial conductor belonging to the undertakers, including its supports and all the structural parts and electrical appliances and devices belonging to or connected with it, shall be duly and efficiently supervised and maintained as regards both electrical and mechanical conditions.

38. *Unused Conductors to be Removed.*—The undertakers shall not permit any aerial conductor to remain erected after it has ceased to be used for the supply of energy, unless they intend within a reasonable time again to take it into use.

39. *Penalties.*—If the undertakers make default in complying with any of the preceding regulations they shall be liable to a penalty not exceeding £10 for every such default, and to a daily penalty not exceeding £10.

The imposition of any penalty under this regulation shall not affect the liability of the undertakers to make compensation in respect of any damage or injury which may be caused by reason of such default.

II.—*Regulations as to Supply.*

1. *Notice of Intention to Supply Through Mains.*—One week at least before the undertakers are ready to commence to supply energy through any feeding, charging, or distributing mains, they shall serve a notice upon the County Council and the local authority of their intention to commence such supply.

2. *Undertakers to Provide Constant Supply.*—From and after the time when the undertakers commence to supply energy through any distributing mains, they shall maintain a supply of sufficient power for the use of all the consumers for the time being entitled to be supplied from such main; and such supply shall, except so far as may be otherwise agreed upon from time to time between the County Council and the undertakers, be constantly maintained at such pressure as may be fixed under the provisions of these regulations. Provided that, for the purposes of testing, the authority by whom the electric inspector is appointed may give permission to the undertakers to discontinue the supply at such intervals of time and for such periods as it may think expedient, and that for any other purposes connected with the efficient working of the undertaking, the undertakers may, with the permission of the Board of Trade, discontinue the supply at such intervals of time and for such periods as the Board of Trade may think expedient. Where the supply is so discontinued notice of such discontinuance, and of the probable duration therof, shall be forthwith served upon the County Council and the local authority.

3. *Maximum Supply from One Section of Main.*—The system of distributing mains shall be so arranged in sections, that in case it becomes necessary to stop the supply through any portion of a main for more than one hour, for the purposes of repairs, or for any other reason, the stoppage of supply will in no case exceed in amount a maximum power of 200,000 watts, or extend to the premises of more than 80 consumers, and in the case of every stoppage for more than one hour reasonable notice shall be previously given by the undertakers to every consumer affected thereby except in cases of emergency.

4. *Pressure in Mains during Supply.*—During the whole of the period when a supply of energy is required to be maintained by the undertakers in the distributing mains under the order and these regulations, it shall be maintained at a constant pressure (in these regulations termed "the standard pressure") to be fixed as hereinafter specified; but such standard pressure may be different for different portions of the distributing mains. Provided that the undertakers shall be deemed to have complied with the requirements of this regulation so long as the pressure does not at any point vary more than 3 per cent. from the corresponding standard pressure, in the case of a general supply at low pressure, or 2 per cent. in the case of a general supply at high pressure, unless changes in pressure recur so frequently as to cause unsteadiness in the supply.

5. *Fixing of Standard Pressure.*—The standard pressure shall be fixed by the undertakers for every pair of distributing mains, and notice of the amount of such standard pressure shall be given to the County Council before the undertakers commence to supply energy to consumers through such mains, and such standard pressure shall not be altered except by permission of the County Council, and upon such terms and conditions as the County Council may impose, and after public notice has been given during a period of one month, in such manner as the County Council may require, of the intention of the undertakers to apply for permission to alter the same. The undertakers may appeal against any decision of the County Council under this regulation to the Board of Trade, whose decision shall be final.

6. *Declared Pressure at Consumer's Terminals.*—Before commencing to give a supply of energy to any consumer, the undertakers shall declare to such consumer the constant pressure at which they propose to supply energy at his terminals. The pressure so declared at any pair of consumer's terminals shall not, except by agreement, be greater than 115 volts or less than 45 volts, if continuous, or the equivalents thereof respectively, if alternating, and shall not at any time be altered or departed from except in consequence of any authorised alteration of the corresponding standard pressure. In distribution on the three-wire system, the central terminal shall for the purposes of this regulation be considered to form a pair with either of the outer terminals, and similarly for multiple-wire systems; and, in the case of a transformation of energy on the consumer's premises, the undertakers shall give the consumer the choice of a supply at either of two different pressures, one of which shall be approximately half the other, and in such case the pressure so chosen by the consumer shall be the declared constant pressure.

7. *Variation of Pressure at Consumer's Terminals.*—The variation of pressure at any consumer's terminals shall not under any conditions of the supply which the consumer is entitled to receive, nor at any time, exceed four per centum from the declared constant pressure, whether such variation be due to the resistance of the service lines or apparatus belonging to the undertakers, or to any action or effect produced by such apparatus, for which the consumer cannot be shown to be responsible, or, partly to any variation of pressure in the distributing mains from which the supply is taken.

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8. *Penalty for Default.*—If the undertakers make default in complying with any of these regulations as to supply, they shall, subject to the provisions of the Order, be liable to a penalty not exceeding £5 for every such default, and to a daily penalty not exceeding £5.

These regulations are made subject to the power of the Board of Trade to make such further or other regulations as they may think expedient; and nothing in these regulations shall be construed to authorise the undertakers to lay any electric line or work their undertaking otherwise than in accordance with the Order and the principal Act, or to supply energy otherwise than by a system for the time being approved of by the Board of Trade under the Order.

ON THE EXPERIMENTS OF HERTZ.*

BY L. BOLTZMANN.

I have successfully demonstrated to a large audience the sparks which pass between a knob and a point in Hertz's experiments on rays of electrical force, by connecting the knob with a very sensitive electroscope, and the point with the pole of a suitable galvanic battery the other pole of which was put to earth. As long as there were no minute sparks or *scintillæ* the electroscope remained uncharged; but when these were formed they established a connection between the knob and the point and caused the leaves to diverge. In this manner I was able to show with certainty the scintilla produced by a single primary spark when the primary and secondary inductors were at a distance of 36·8 metres apart, the greatest distance available.

At a distance of 8·7 metres all the Hertz experiments could be most conveniently demonstrated before an audience of about 200, so as to be visible to every one; only three or four primary sparks were required for each experiment, by which the electrodes could be kept brightly polished. Dust, cracks in the metal, or an impure greasy condition of the surface, appeared more injurious than the layer of oxide: cleaning with dilute sulphuric acid, distilled water, and then dry rubbing was found to be best; a thicker layer of oxide is removed by polishing with French chalk (moistened with spirit), in which case dry rubbing is sufficient. I was not able to perceive any advantage in a current of air as recommended by Dr. Classen.

The length of the secondary spark produced at the great distance of 36·8 metres I estimated at $\frac{1}{3000}$ millimetre as the maximum. As the dry pile which served to charge the electroscope had a potential of 200 volts, the knob and the point were adjusted at a distance which exceeded by about $\frac{1}{3000}$ the striking distance of the dry pile, the discharge of which was then set up by the addition of Hertz's waves to the tension of the dry pile. By using a much more feebly charged battery instead of the dry pile, and a much more delicate galvanoscope, Hankel's for example, the rays might be perceived at still greater distances. In the latter case it might not be impossible to measure the deflexion with a view to quantitative determinations. The regulation of the distance between the knob and the point must then be made so much the finer.

I also made experiments on interference by reflecting the waves from the primary parabolic mirror through two plane mirrors, which, like those of Fresnel, formed an obtuse angle, and whose planes were at a distance of fourfold a half wave-length. This method seems well suited for accurate measurements of the wave-length and of the decrement of the vibration.

AN EASY MODE OF PRODUCING THE ACTIVE SPARK IN HERTZ'S EXPERIMENTS.*

BY H. CLASSEN.

In repeating Hertz's experiments in the State Physical Laboratory at Hamburg, an observation was made which shows how in a simple manner we can overcome the difficulty experienced by many observers of keeping the primary spark effective for a long time together. In the same manner in which Rijke used the action of a current of air on the make-and-break spark of an induction-coil in order to produce a stronger action in the secondary coil, so may the spark of the coil itself, and therefore also its inductive action on any other conductor, be similarly influenced.

In the experiments a large Ruhmkorff's coil was used which had a very rapid contact-maker, and which gave sparks up to 14 centimetres. If the ends of the secondary coil are loaded with conductors, and the discharging knobs are brought within a distance of a few centimetres, the discharge takes place mostly in the form of a continuous rose-coloured strip of light, and is useless for Hertz's experiments. But when this band is blown away so that flames a centimetre in length project on the side, sharp brightly luminous sparks occur between the knobs. The current of air produced by a Müinke's water-pump was now blown continuously between the knobs, and thus a series of sharp cracking sparks passed quite continuously, and could without difficulty be continuously maintained for hours. A series of Hertz's experiments could now be repeated, and even when the current of air was replaced by one of steam the action was the same. The whole process suggests the idea that, in the ordinary discharge with a luminous band of light, detached metallic particles effect a permanent conduction, and that the essential discharge-spark is only produced as these particles are blown away. The influence of the ultra-violet illumination, too, which has been designated by various observers as highly disturbing, would, after the researches of Lenard and Wolf on the pulverisation of bodies by illumination, in this find an explanation.

* Abstract from the *Phil. Mag.*

THE COUPLING AND CONTROL OF DYNAMOS IN CENTRAL STATIONS.—II.*

(Continued from page 433.)

The main electrical governor in the last arrangement discussed can be made very accurate by means of relays balanced against a large Clark or other standard cell, and can also be made to respond very slowly, so as to avoid any chance of making the whole station "hunt." The slowness of response permissible depends on the quickness of variation of boiler pressure, and of variation of station load. Even with tubular boilers, such as Fashion, who is as autocratic in engineering as in dress, dictates for modern stations, the variation of steam pressure is not rapid, and the load on a central station also varies very slowly. High-speed engines with very little inertia are also in vogue just now, so it is easy to make a general station governor free from any danger of hunting. Many people would regard a Clark cell as unable to control a relay of sufficient power to be safe; but these cells are made small for balancing by Poggendorff's method with a sensitive galvanometer. A large Clark cell will give a fair current without damage. Almost any cell is more accurate than a voltmeter or solenoid arrangement. A secondary battery, for instance, balanced against the station pressure will give a very large power with a small variation of pressure.

As the governor may sometimes go wrong, and raise the E.M.F. throughout the station, thus breaking some thousands of lamps, it would be risky to give it complete control of a station, and to rely upon it absolutely. Controlling by hand is expensive, and is apt to be intermittent or occasional. It would therefore be infinitely better to combine the advantages of both systems by allowing the governor complete control within a margin of, say, 1 per cent., and relying on a thinking being for large adjustments. When the governor reaches the end of its tether, an attendant turns the whole station a half per cent. up or down, as the case may be. This must be done very slowly, so that the governor can have time to counteract it, thus keeping the pressure really constant. The governor is thus left at the middle of its range again. The control of an incandescent lamp station within a tenth per cent. or so is of enormous importance in connection with efficiency and lamp renewals.

Instead of electrically governing the engines the ordinary speed governors may be used, and the dynamos may be controlled by varying their excitation. The engines do not then really need to run at constant speed; all that is necessary is that for every speed there shall be a determinate steam supply, or, if the boiler pressure varies, that the speed will be constant within the limits of safety of the engine. Regulation by excitation then really becomes a roundabout method of controlling the steam supply, and nothing more. For if a machine is giving 100 volts and 1,000 amperes, the station pressure being 100 volts, and it is required that that machine shall only give 500 amperes and 100 volts, the field is weakened. If the engine had the same cut-off, so that its torque was constant, the speed would increase till the torque was as before. But as the field is weaker, this torque can only be obtained by delivering a current greater than 1,000 amperes. An engine giving constant torque driving a dynamo on constant pressure is thus in unstable equilibrium. Suppose, however, that the cut-off or throttle valve is controlled by a speed governor, on weakening the field the engine increases its speed till the governor cuts the steam down, and by weakening the field enough, the engine runs up till the steam supplied only gives a torque which, with that field, corresponds to 500 amperes. The regulation of the field is thus merely a method of turning on or off the steam, and nothing more. Of course, these remarks only apply completely to central stations under the conditions discussed. The regulation of the field of a dynamo driven from a shaft, which also drives, say, a machine shop, is not the

* Abstract of an article by Mr. James Swinburne in *Industries*, Aug. 22nd.

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same, as the speed of the shaft, and therefore the governor and steam supply, do not wholly or even mainly depend on the torque in the dynamo.

In a station with each engine governed for speed it is perhaps best to arrange the governor so as to admit a fair variation of speed between no load and full load, as such governors are more easy to make, and in this case will do as well or perhaps better than if they were nearly isochronous.

As the load on a station increases the engines will need more steam, and to get this they must run slower. The fields must therefore be strengthened. In the case of shunt machines, which have a falling characteristic, as must especially be the case in large single-magnet dynamos, the variation of excitation necessary is considerable. To vary the station pressure all the shunts must be altered together; to vary the proportion of the load taken by each steam dynamo each field must be altered independently. At the St. James's and Pall Mall station in Mason's-yard, Mr. Dobson has arranged the shunts so that each is controlled independently by a lever, but all these levers can be thrown into gear with a master lever whatever their relative positions, and can then be controlled together. The master lever controls the pressure of the whole station, and the individual levers the proportion of load taken by each steam dynamo. If an electric pressure governor were used it would control the master lever. When shunt machines are used the margin for control must be great.

Compound machines may be coupled to run in parallel by Mordey's method of connecting all the brushes as well as the terminals. These connections are a little expensive, but, as will be explained, they save cost in other directions. The control is just the same as in the case of shunt machines, but there is the great difference that with uniform, or nearly uniform, boiler pressure the whole station compounds, so that there are no fluctuations of pressure caused by variations of load, or by putting in machines or cutting them out. In large machines, with great back induction, this means a great saving of resistance and regulating appliances. As a rule, station dynamos are only at light loads at the instant of coupling in, the working range being from half to full lead. If they are to be coupled in at full speed, the resistances for controlling a shunt machine must be enough to cause the whole variation of field. Generally a shunt machine is put into circuit at a lower speed with full field; but in any case it is advisable to have resistance enough to go through the whole range of the dynamo. This means a very large resistance board, and a very large drain of electrical power going to waste. Ten dynamos of 100,000 watts each may thus waste two or three horse-power among them on adjustable resistances. With compound machines nearly the whole of this waste can be saved. There seems, therefore, to be a heavy balance in favour of compound machines for station work.

Parallel coupled stations without batteries give most trouble when feeders are used. Feeders may be worked in several ways. The station pressure may be kept uniformly high—say, 2 per cent.—and the feeders may be thrown in as the load increases in such a way that there is always 2 per cent. drop in them. It may be preferable to make the whole station "compound up" a little—that is to say, give a higher pressure when the load is heavy. When feeders are not used this improves a direct supply. For instance, when the mains are arranged concentrically round the station with radial feeders, as at the Pall Mall station already mentioned, if the lamps are all 100 volts, the station may give 100 volts at light loads, so that all the lamps then have 100, the drop being negligable; at full load the station runs up to 101 volts, and the near lamps get 101, the medium 100, and the distant 99 volts, giving a maximum variation of only 1 per cent. This principle is equally applicable in the case of feeders, and lessens the cost and complication of the systems. The case of concentric service mains supplied by radial feeders is a particular case of districts fed by connecting feeders with no network of mains connecting the districts. In the case of a larger area, additional feeders can be run direct to the outlying districts. If the districts are all provided with lamps for the same pressure, and if the station is run in parallel, there must always be considerable waste of power in the feeders, unless the compounding-up half-way method is adopted; for the distant lamps must have full pressure, so the whole station must be run with the additional pressure lost in the feeders. In some cases the feeders are not thrown in and out, but have resistances inserted in them. The Edison station at Boston, for instance, is run this way. A certain percentage of the power of the station is then always allowed to run to waste either in resistances or in feeders. A great deal of this loss can be saved, however. Instead of arranging the feeders and resistances so as to have a constant drop in them the whole of the day, they may be regulated so that at any given time the drop in all the feeders is the same, though at different times the drop differs. For instance, in the day the station may be run at 100 volts with all the resistances out of all the feeders, so that there is no waste. In the early evening a shop district may be at full load, having a drop of two volts, while a residential district has a drop of one. The station is then run at 102 volts, and one volt is lost in resistance in the residential feeders. When the shop and residential district feeders each lose 1 volt, the station runs at 101 volts, with no resistance in either, and so on. The principle of "compounding-up" may also be applied here to some extent. The saving is very large compared with a constant drain, which is probably under-estimated at 2 per cent.

The feeder difficulty may be more economically treated by dividing the station into two parts. One is run at from 100 to 101 volts, and the other at from 100 to 102, according to the time of day. The distant feeders are connected to the latter part of the station, and the nearer districts are worked from the former. With a three-wire system this means no less than four divisions of the central station plant; but the connections and switchboards are but little more complicated than if the machines all run in parallel on direct supply. Of course, battery systems admit of feeder regulation in the greatest perfection; but the advocates of batteries are a little apt to overlook the extra cost of the switches and connection gear, and the troubles involved in uneven discharge of some of the cells.

(To be concluded.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 15, 1890.

Meeting of the National Electric Light Association.—The principal event in electrical circles just now is the coming meeting of the National Electric Light Association at Cape May. It promises to be very largely attended, and a number of out-of-town electricians are now in the city, on their way to the meeting, which will open on Tuesday morning next, and continue during the three following days. A large number of interesting Papers are promised, and some important Committee reports will be presented. The work of the Association itself is gradually growing in importance from year to year, and much good can be accomplished through their aid, because the National Electric Light Association represents more completely than any other organisation the electrical interests of this country.

Meeting of the American Association for the Advancement of Science.—During next week, too, the American Association for the Advancement of Science holds its annual meeting in Indianopolis. The report of the Papers to be read has not yet been made public, but it may be safely assumed that some at least of them will be of special interest to electricians. In years past some very important work has been done by the American Association, even in practical electricity, and there is a strong probability that the present meeting will be no exception to the rule. These meetings are usually well attended, although but small compared with the immense gatherings at the meetings of the British Association, owing to the scattered nature of its membership.

Storage Battery Cars.—Some progress seems to be made in equipping the Fourth Avenue street-railway with storage battery cars. For a long time only a single car was in operation, but the United Electric Traction Company, the successors of the Julien Company, are now putting on cars as rapidly as the batteries can be turned out of the factory and placed in position, and a tolerably complete service is promised ere long. Speaking of storage battery cars, a new one has just been tried on the Seventh Avenue surface line with a fair degree of success. It is the MacDougal storage battery car, and while not radically different from the others now in use, it presents some admirable mechanical features.

The Van Depoele Closed Conduit System of Electric Traction.—Mr. C. J. Van Depoele, of the Thomson-Houston Company, has recently patented a closed conduit specially for electric traction service. It consists of a small subway laid in the usual position and furnished with a slot in which the contact plough runs as usual. A peculiarity of the system is that the slot is completely closed except where it is held open by the plough under the car by a pair of flexible lips of insulating material—rubber or its equivalent—so that dirt and water are

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in great measure excluded from the conductors. Of course, very little can be said regarding the practical effectiveness of this plan until it has been given trial on a large scale; but if the slot closing material can be made sufficiently durable, many of the difficulties of insulation would appear to be overcome.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *August* 21, 1890.

The manufacture in Sweden of various electrical appliances is constantly increasing, and several of the articles have attracted considerable attention outside this country, as, for instance, both dynamos and telephones, electric wires, &c. Sweden is also now doing a fair export trade in incandescent lamps, especially to Russia. The principal makers, R. W. Strehlenert and Co., of Stockholm, have just executed an order from Norway for 10,000 incandescent lamps, and are altogether doing a very good trade. The Elektriska Aktiebolaget in Stockholm has during last year sold 38 dynamos of 501 electrical horse-power, and installed 4,234 incandescent and 16 arc lamps. Among last year's more important installations were the central electric stations at Arboga and Östersund, comprising about 120 subscribers and 200 street lamps. During this season 156 dynamos of 1,880 electrical horse-power have been made at the Company's works, and 17,400 incandescent and 35 arc lamps have been installed. For the past two years the Company has paid a dividend of 5 per cent.

During the first half of the present year the number of telegrams in Sweden amounted to 440,309 inland and 368,832 foreign, the receipts amounting to 308,633kr. and 336,927kr. respectively. There was an increase in the number of telegrams, as compared with same period last year, of 19,732 messages, or 2·5 per cent., of which 11,784 telegrams were inland ones; the receipts have, however, decreased by 3,359kr.

There have been a great many heavy thunderstorms lately, both in Denmark and Sweden, and much damage has been done to property, and several fatalities have occurred. The lightning has in some places acted in a most capricious manner. At one place, at Suöresjö, in Sweden, it did a great deal of damage in a house—split up a lot of woodwork, tore the wall paper from off the walls, &c. The greatest damage was done in two rooms, where, altogether, ten people were asleep, but none of them sustained any injury. At Nestoed, Denmark, some men, who had been repairing a lightning conductor, had just left it when the lightning struck it.

CORRESPONDENCE.

ELECTRICAL NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The importance of the above subject must be my excuse for troubling you with a few remarks on Dr. Fleming's letter, published in your last issue, especially as the writer, in his final sentence, invites discussion.

On this side of the Atlantic we will, I am sure, be only too ready to entertain the proposal of our American colleagues to embody the names of Henry and Franklin in the system of practical electrical units. But in addition to the principle adopted by the British Association Committee in 1862 of forming the names of practical units out of the surnames of distinguished investigators, it seems to me that a subsidiary condition should not be lost sight of. It is this: that the name or the contraction of the name by which any unit is to be known should not be identical with or even closely resemble any word in common use to which other associations are attached. Up to the present, the names that have survived have fairly well fulfilled this subsidiary condition, though the word "watt" sails somewhat close to the wind in this respect. But Dr. Fleming's suggestion to adopt the word *hen* as the practical unit of self-induction opens up a vista too terrible to contemplate. One cannot, indeed, resist a suspicion that the learned doctor, by his suggestion and by the remorseless way in which he follows it out to its logical results in speaking of *true hens*, *legal hens*, *henmeters*, &c., intends to demonstrate once for all that the word *Henry* is quite intractable for the purpose in view. Even if the full name were taken it would be apt to degenerate, at least with Cockneys, into a too well-known abbreviation.

There is another consideration which should also be borne in mind, and that is, that there are living "distinguished investigators" who have certainly earned the right to have their surnames canonised in this way. It would be well, therefore, not to be in too great a hurry to cover all the ground. Moreover, we have no unit whose name is derived from the honoured name *Maxwell*, a word which looks at first sight not very tractable, though perhaps the ingenuity of word-coiners may yet make something of it.

Turning now to Dr. Fleming's other proposals, I agree with him that the term "magnetic resistance" should be dismissed, but I would replace it by Mr. Oliver Heaviside's term "magnetic reluctance," which seems to express neatly the ideas that underlie the phenomena as we at present view them. Just as the reciprocal of resistance is conductivity, so the reciprocal of reluctance could be known as *receptivity*, or, still better, *receptance*, the old term "permeability" being retained for the "specific receptance" in C.G.S. units. The word "permeability," except for the fact that it is one syllable longer, seems preferable to "pliability," and is already well known.

Dr. Fleming's definition of the practical unit of the total flux of magnetic induction and the name that he proposes for it are urgently needed for practical work, and I hope that they will be adopted, though personally I should prefer the full word *gilbert* instead of the contraction *gilb*, which could, however, be used by those who are laconically inclined. Again, I should prefer the full word *franklin* to the contraction *frank*, especially as the latter trenches upon familiar associations. But I hope that Dr. Fleming's definition of the *frank*, by whatever name it may be known, will be simplified. Supposing the ampere and the ohm already fixed we should scarcely proceed to define the volt "by the condition that a uniform slope of electric potential along an electric circuit of one volt per centimetre of length produces an electric current of one ampere per (square) centimetre of cross-section in that circuit, when that circuit consists of material of unit specific resistance." This definition, however, would be correct. In the definition proposed for the gilb(ert), it is recognised that the total magnetic induction is more important than the "density of or intensity of induction." Why not consistently follow out this idea by defining the frank(lin) as that magneto-motive force which will produce one gilb(ert) in a circuit of unit magnetic reluctance? If, in addition, we take as the practical unit of magnetic reluctance, one-millionth part of the C.G.S. unit, then the frank(lin) would be 80 ampere-turns, to the same degree of approximation as is used by Dr. Fleming for his "microfrank." The specific reluctance of air and non-magnetic materials would be 1,000,000 of these practical units, a fact which would serve to impress on the minds of practical men the great influence which an air-gap has on the reluctance of a circuit. A convenient name would doubtless soon be found for this unit of reluctance.

The chief difficulty, however, is with regard to the tables of "specific reluctance," from which the total reluctance has to be calculated. But Dr. Fleming's suggestion only appears to remove the difficulty for those circuits which are of uniform cross-section, and of the same kind of material throughout. These are not the circuits with which we have frequently to work in practice; instead we have circuits of wrought and cast iron of different cross-sections with air-gaps interposed. One obvious way out of the difficulty is the following:—The total number of gilb(ert)s required is generally known, at least approximately; the cross-section of iron where the magnetic flux is greatest can also be approximately assigned. Tables (or preferably curves) could be constructed giving the specific reluctance of the particular kind of iron for various magnitudes of the magnetic flux, in gilb(ert)s per some unit of area which would be most convenient for practical men, and from these a calculation could be made of the reluctance of the whole circuit, with recognised allowances for leakage in standard cases. The requisite magneto-motive force in frank(lin)s could then be calculated by the Ohm Law rule.—Yours, &c.,

R. MULLINEUX WALMSLEY.

Heriot-Watt College, August 26, 1890

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"CATAPHORIC MEDICATION."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your Note on "Cataphoric Medication," which term I believe I am responsible for, you are good enough to remind your readers that the process is regularly practised at the Institute of Medical Electricity. So true is this, that I am hoping shortly to bring before one of the learned societies a considerable series of actual cases in which cataphoresis has been practically applied with satisfactory results. At a lecture on November 5, 1889, to a class of medical men and nurses, at the Institute, I showed cases, including rheumatoid arthritis, under this treatment. At the meeting of the Brussels Medical Graduates' Association, in December, 1889, I again spoke on the subject; and in a letter to the *Medical Press* on December 11, 1889, I described in some detail the process employed in my cases. I am very glad to be supported by so well-known an electrician as Mr. Edison in the investigation of this subject; but I think he is a little late in the field, though he has been somewhat premature in the publication of a solitary case which was only "temporarily ameliorated."—Yours, &c., ARTHUR HARRIES, M.D.

14, Suffolk-street, Pall Mall, August 23, 1890.

A LONG-LIVED INCANDESCENT LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was surprised to read on page 397 (August 15) that 3,500 hours is considered to be a "phenomenal" life for a modern incandescent lamp. I have before me a 100 volt 16 candle-power Edison-Swan lamp, which has a record of 6,011 hours. This is one of 430 installed in the Victoria Hotel, Manchester, in March, 1888. One of these is still doing duty, never having been disturbed except to clean the shade occasionally, and then not removed from the socket. This lamp has a record of 10,418 hours up to noon to-day. It has been repeatedly run at 110 to 115 volts, though only for one to six or seven minutes consecutively. On one occasion during the early days of its existence it was, together with about 200 other lamps, subjected to an E.M.F. of 120 volts for some fifteen to twenty minutes. At this time twelve lamps gave out, but not so the above-mentioned "phenomenal" lamp.

O! si sic omnia! Should the filament ever give out I will advise you of the fact.

Mr. R. Boyd, the engineer in charge, can vouch for the accuracy of the above statements. I should add that the average life of the lamps has been over 2,000 hours.

One of my clients, who habitually runs his lamps (100 volts) at 130 to 140 volts, finds that the average life is rather over 200 hours.—I am, yours, &c., J. LAVENDER, JUNR.

Manchester, Aug. 26, 1890.

[It will be interesting to see whether Mr. Lavender's undoubtedly phenomenal lamp will be longer lived than the one referred to in the *Electrician* of November 22, 1889, by Mr. O. V. Thomas. This lamp did duty for 10,608 hours, and also suffered somewhat from overrunning.—ED. *E.*]

"GLOBULAR LIGHTNING."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The full particulars given by Mr. Adamson in your number of the 22nd inst. of this form of electricity are very important, he and the boy having both seen the ball moving, The spheroidal state of electricity is one among other proofs that this element possesses a certain amount of attraction of cohesion for its own particles. If it did not possess attraction of cohesion it would never exist as a sphere, and is a proof that it does not possess repulsion for its own particles; which latter doctrine is a part of Faraday's delusion, that electricity is two forces, each individually repellent to itself.—Yours truly,

JAMES JOHNSTONE.

Laboratory, Dalhousie-terrace, Edinburgh,
August 25, 1890.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The British Foreign Office announce that the Spanish Minister of the Interior, by a notice dated the 18th inst., invites tenders for the construction of a line of telegraph cables between Spain and the Spanish possessions on the north coast of Africa, and to Tangier. Seven sections will be required, of a total length of 332 miles. The maximum payment to the contractor is not to exceed £160 per mile. Tenders, in sealed covers, are to be addressed to the Director of Posts and Telegraphs, Telegraph Department, No. 18, Calle d'Claudio Collo, Madrid, on or before September 17th. The conditions of the contract (in Spanish) can be seen at the Commercial Department of the Foreign Office, Whitehall, between 11 and 5.

MESSRS. DRAKE AND GORHAM.—We understand that Messrs. Drake and Gorham have found it necessary to double the size of their existing offices to find accommodation for the additional *employés* which they have been obliged to take on, owing to the rapid increase of their business.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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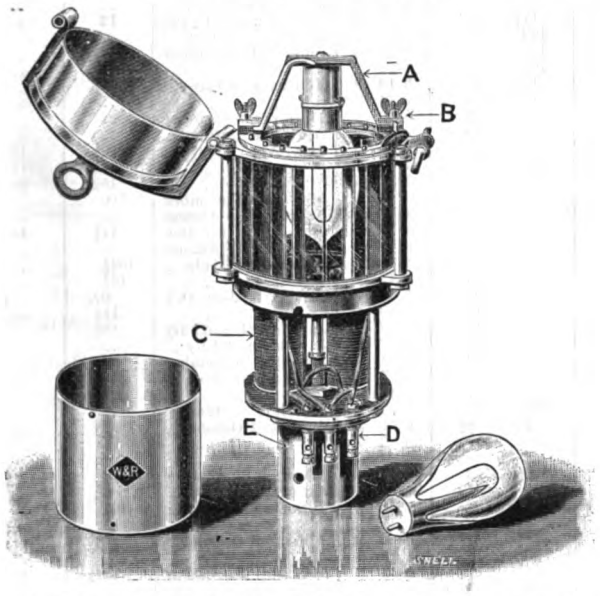
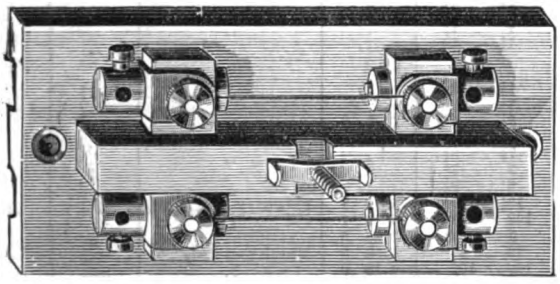
SCOTT'S FLASH-SIGNALLING LANTERN.—This lantern, the invention of Commander Percy Scott, R.N., is manufactured by Woodhouse and Rawson United (Limited), and was fully described in our issue of June 20th, p. 171. The accompanying block shows Commander Scott's lantern with its shutters open, when no current is flowing, and with its cover and tube removed to show the



inner details. A is the holder, which, by unscrewing the fly nuts B, enables the lamp to be at once removed for the substitution of a new one; at C are two magnet coils, actuating the armature; and at D are three terminals respectively joined to the magnet coils, the lamp, and one dynamo terminal. The framework supporting the shutters is removable. E is a stout tube enabling the lantern to be fixed on the top of a mast, to which it is pinned through the hole seen in the side. It can also be suspended from the ring attached to the cover.

BINSWANGER'S IMPROVED "H.I." CUT-OUTS.—An excellent form of cut-out has been introduced by the General Electric Company,



the construction being very well adapted for maintaining a high insulation from earth. The body and the cover are of china, and the metal parts are carried on ribs moulded on the body, thus avoiding any appearance of screws at the back. The filling up of the back of fittings with insulating material to prevent leakage from screw heads is not reliable, and the arrangement of the "H.I." cut-out not only dispenses with this, but in single pole cut-outs provides a wall of china separating the conductors from the fuse. The large sizes are provided with tinned thimbles for sweating on to the ends of the cables. The covers are readily removable, and the fuses are easily got at. The accompanying illustration shows a double pole cut out, an article of which we do not approve, but which is sometimes demanded.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED.—This Company have entered into a contract with the London Road Car Company for the supply of 60 omnibuses for horse traction. These omnibuses will be constructed at the Brush Company's Falcon Works, Loughborough, where large extensions have been made to enable the Company to cope with the increasing demand for their steam engines, tram cars, and omnibuses for electric or other traction, rolling stock, and electrical machinery and apparatus of every description.

NEW COMPANIES REGISTERED.

CERES IRONWORKS (LIMITED).—Registered with a capital of £15,000 in £10 shares. Object: To carry on the business of general and mechanical engineers, metal founders, and implement makers, &c., at the Ceres Ironworks, Kingston-on-Thames.

UNITED FLEXIBLE METALLIC TUBING COMPANY (LIMITED).—Registered with a capital of £75,000 in £10 shares. Objects: To acquire and amalgamate the undertakings of the Flexible Metallic Tubing Company (Limited), incorporated in 1886, and of the Belgian and Colonial Flexible Metallic Tubing Company (Limited), and to carry on the business of manufacturers of and dealers in flexible and other metallic tubes, &c.

VAUGHAN-SHERRIN ELECTRICAL ENGINEERING COMPANY (LIMITED).—Registered by Lowles and Co., 26, Martin's-lane, E.C., with a capital of £25,000, in 4,975 ordinary shares of £5 each and 25 founders' shares of £5 each. Object: To carry into effect an agreement, made August 11th, between John Vaughan Sherrin of the one part and Richard Frederick Dempster, on behalf of the Company, of the other part, and to manufacture electric motors, generators, tricycles, bath-chairs, boats, and machines, or any carriage, vessel, or machine, either wholly or partly propelled or worked by electricity, upon any system whatever, and for carrying on the business of electrical and mechanical engineers, and all manufactures connected therewith or relating thereto. Mr. John Vaughan-Sherrin is appointed Managing Director at a salary of £300 per annum.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 22nd amounted to £5,121.

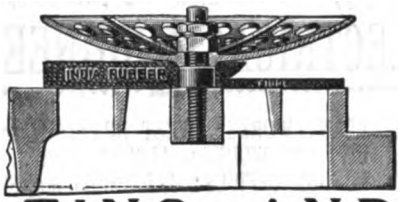
ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED).—We are informed that better prices for their manufactured goods are being obtained by this Company than was expected, and that a saving has been effected upon cost of manufacture. The £2 shares of this Company have recently touched £8, and closed yesterday at £7. The formation of the Elmore Wire Company no doubt contributed largely towards providing the funds for the big dividend the parent Company has been able to pay. We must wait till we are supplied with statistics as to cost and have experience of the value of the products of the Company before deciding whether the quotations given above represent the real value of the shares. The tubes and wire shown by the new Company at their offices in Queen Victoria-street certainly go far to bear out the sanguine views of the Directors, and to prove the commercial value of the process. We are informed that the Company has large orders on hand.

STOCK EXCHANGE.—The Committee have ordered the under-mentioned security to be quoted in the official list:—Electric Construction Corporation (Limited), shares, Nos. 101 to 45,100.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 22, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,994.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 20th Sept. 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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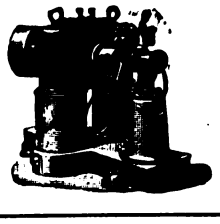
COMPANIES' SHARE LIST.

PRESENT AMOUNT.	AMOUNT OF SHARE.	LAST DIVIDEND.	NAME.	PREVIOUS WEEK'S PRICE, AUG. 20.		Price Wednesday, Aug. 27.		RATE PER CENT. YIELDED.	DIVIDEND DUE.	BUSINESS DONE DURING WEEK ENDING AUG. 27.	
										Highest.	Lowest.
£			**TELEGRAPHS.**					£ s. d.			
1,381,330	Stock	15/0	Anglo-American	50½	51½	50½	51½	5 6 10	Jan., Apr., July, Oct	50⅝	..
2,809,310	Stock	30/0	Do. Preferred	87	88	87½	88½	6 4 4	,, ,,	88	87½
2,809,310	Stock	..	Do. Deferred	14¾	15¼	15¼	15¾	.. ..		15 9/16	14⅜
25,000	£100	4%	African Direct, 4 per Cent. Debentures	97	100	97	100	4 0 0	January and July	..	—
130,000	10	3/0	Brazilian Submarine	11⅜	12¼	11⅜	12½	5 6 1	Mar., June, Oct., Dec.	12	11⅜
69,200	100	5%	Do. 5 per Cent. Bonds	100	102	100	102	4 18 0	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	103½	..
..	$100	..	Commercial Cables	103	105	102	104	.. ..		..	..
15,000	£10	9/0	Cuba Submarine xd	12⅛	13	12½	13	6 10 9	February and August	12½	..
6,000	10	10%	Do. Preference 10% xd	16⅛	17½	16½	17½	5 14 3	,, ,,	..	..
12,931	5	5½% 1889	Direct Spanish (£4 paid)	3⅛	4	3½	4	5 10 0	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10⅛	10⅜	10½	10⅜	6 15 0	Jan., Apr., July, Oct.	10½	10½
400,000	10	5/6	Eastern	13⅞	14½	13⅞	14½	4 12 0	,, ,,	14½	13¾
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	,, ,,	15⅜	15
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106	107	108	109	3 13 5	May and November	106	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14	14¼	14	14½	4 16 7	Jan., Apr., July, Oct.	14½	14½
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	104½	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	100	103	100	103	4 17 1	,, ,,	101	..
180,227	10	4/3	Globe Telegraph and Trust	8⅞	9½	8⅞	9½	5 9 7	Jan., Apr., July, Oct.	9 1/16	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅝	15⅝	14⅝	15⅝	3 19 4	,, ,,	15⅝	14⅝
150,000	10	5/0	Great Northern	15½	16	15½	16	4 13 9	Jan., April, and July	15½	..
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100	103	100	103	4 17 1	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	106	109	106	109	4 11 9	March & September	..	..
17,000	25	37/6	Indo-European	37	39	37	39	6 7 2	April and October	..	..
38,348	10	4/0	London Platino-Brazilian	6	7	6	7	6 15 9	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	107	110	107	110	5 19 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞	8½	7⅞	8½	6 1 3	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	113	117	113	117	5 2 7	,, ,,	..	..
15,609	£10	6/6	West African	9	10	9	10	5 0 0	.. ..	..	..
200,000	100	5%	Do. 5 per Cent. Debentures	100	103	100	103	4 17 1	March & September	102	101⅝
30,000	10	3/0	West Coast of America	3	5	3	4	.. ..	January and July	3⅝	3 1/16
150,000	100	8%	Do. Debentures 8%	106	110	103	108	7 8 2	June and December	105½	..
88,321	10	Nil.	West India and Panama	2⅞	3	2⅞	3	.. ..		3	2⅞
34,563	10	6/0	Do. 1st Preference 6%	11½	11⅞	11½	11⅞	5 2 2	April and October	11⅝	11⅜
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	13	14	13	14	4 5 9	.. ..	..	..
61,572	15	6/0	Western and Brazilian	11	11½	11½	11⅝	5 2 3	May and November	11 1/16	11⅜
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6½	7	6⅝	7⅛	.. ..	..	..	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	5	5½	4¾	5⅛	.. ..	..	5⅛	4⅞
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103	106	103	106	5 13 2	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101	104	101	104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	101	99	101	5 18 10	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5¾	Consolidated Telephone Const. and Maintenance	1 0/16	1 1/16	1 0/16	1 1/16	.. ..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	¼	⅜	¼	⅜	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅞	5⅛	4⅞	5	6 0 0	June and December	4 1/16	4 1/16
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12	12½	12	12½	4 16 0	June and December	12 1/16	12⅛
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10	10½	10	10½	4 11 9	,, ,,	..	..
209,750	1	⅛	South of England, Ordinary	⅛	⅜	⅛	⅜	.. ..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd)	2½	3	2½	3	6 19 11	..	..	..
55,000	5	1/0	United River Plate	3½	4½	3½	4½	.. ..	January and July	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	1⅞	2⅛	1⅞	2⅛	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4	4½	4	4½	..	..	..	..
42,853	5	..	Westminster Electric Supply	1¼	1¾	1¼	1¾	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1⅞	2	1½	2	..	..	1¾	..
63,416	2	1/2	Do. Preference	1⅞	2	1⅞	2	..	..	1⅞	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5⅛	5⅜	5½	5⅝	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	7¾	8¼	..		..	..	..	..
409,000	10	..	Electric Construction	..		7⅜	8⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	6	6½	7	7½	..	..	7⅜	6⅝
20,000	5	..	Fowler-Waring Cables	2	2½	2	2½	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18½	19½	18½	19½	5 2 7	February & August	18½	18½
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5	5½	5	5½	3 16 5	..	5	..
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43½	42
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100	102	100	102	4 18 0	..	100½	..



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(Statter's) WRITE FOR THE FOLLOWING PAMPHLETS TO THE (United)

ELECTRICAL ENGINEERING CORPORATION, Ld.

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"ELECTRICAL DISTRIBUTION."—Commercially considered, with Estimates.
"MACHINE DRIVING BY ELECTRICITY."—The Uses of Electro-Motors for Traction and Stationary Purposes.
"THE TELPHER SYSTEM OF CHEAP TRANSPORT," for Minerals, Goods and Passengers.
"ELECTRICAL SUPPLIES."—Prices and Particulars of the most approved Electrical Appliances

ELECTRICAL PLANT ON VIEW.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 642.—Vol. XXV. FRIDAY, SEPTEMBER 5, 1890. Price Fourpence.

NOTES.

The Presidential Address delivered yesterday by Sir Frederick Abel before the British Association at Leeds was of a length commensurate with the importance of the occasion, and contained a large amount of matter of considerable interest to electricians. No one is better qualified than Sir Frederick Abel to speak on what may be termed "military chemistry;" and although he had, of course, much to tell us with regard to smokeless powders and modern explosives generally, he by no means confined himself to that particular branch of applied science with which his name is so intimately connected.

Electricity and the progress it has made since the Leeds meeting of 1858 formed the theme of an interesting historical review. What has been accomplished in this direction during the last thirty-two years is well known to us all; but we think that it will come as a surprise to many to hear that thirty-four years ago Joule had closely studied the question of welding metals by electricity, and seems, indeed, only to have been prevented by the lack of suitable electrical generators from making that practical application of his investigations which has been made in our day by Elihu Thomson. A careful search into the scientific records of the past would no doubt reveal many similar correctives to our exalted notions as to the wonderful nature of the advances of the last decade or so.

One fact greatly emphasized and amply illustrated by Sir Frederick Abel in the course of his address was the action and reaction between theory and practice which is ever going on; and his remarks on "the invaluable aid afforded to purely scientific research by the practical results of the development of electrical science, and of the constant co-operation between the science student and the practical worker," are well worthy of perusal by those super-energetic spirits who are ever seeking to start barren discussions as to the relative utility of theoretical and practical men, and to apportion in a hard and fast manner their respective shares in the advancement of science

The concluding portion of the President's address dealt with Technical Education and Science Museums, and contained a handsome eulogy of the public spirit shown by Guilds of the City of London in so munificently endowing this department of education. "To have been first in the field in practically developing a far-reaching scheme for the advancement of technical education in this country must," said Sir Frederick, "continue to be a source of pride to the City of London and its ancient Guilds in time to come, when the operation of efficient legislation, supported and extended by patriotic munificence and by the hearty co operation of associations of earnest and competent workers in the cause, shall have placed the machinery and resources for the technical instruction of the people upon a footing commensurate with our position among nations."

The employment of electrical methods in chemical research is becoming more and more common. The study of the electric resistance of solutions has already been of service in investigating their nature; and, in the hands of Prof. Mendeléeff and his followers, has resulted in the discovery of new compounds. The close connection between the electromotive force of a cell and the energy corresponding to the thermal actions within it was pointed out many years ago by Sir W. Thomson, and is now chiefly used to determine the chemical actions within the cell. Electrical methods are, however, not so much used in chemical research as their importance warrants; and the valuable Paper of Dr. Gore, an abstract of which we reproduce in another column, will be serviceable in this connection by bringing the subject prominently forward.

Electrical methods of test are far more sensitive than chemical ones, since with the former the tendency to chemical action is measured, while with the latter it is only after the action has gone on for some time that a sufficient product is formed to be recognisable by chemists. The electrical method is, in fact, so sensitive that great care and skill are needed to reproduce results; and the employment of pure materials is absolutely necessary, since the presence of slight traces of foreign substances, too minute to be detected chemically, is sufficient to alter the indications. The simultaneous study of the electrical properties of analogous chemical compounds, although of great importance, has not before been attempted; and the relations brought out by Dr. Gore between electromotive force and molecular weight are very interesting and suggestive. The seat of chemical energy in the voltaic cell is clearly indicated by the curves, showing the effect of varying the strength and temperature of the solution at one electrode; while the employment of the method to detect the influence of light, heat, &c., on different solutions may lead to a more accurate knowledge of the conditions necessary for the formation of a good standard cell.

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In another column will be found an abstract of a recent article in the *Electrical World* of New York, which would appear to afford a striking argument in favour of the use of high-speed engines coupled direct to the dynamos for electric traction work. About this time last year Dr. Louis Bell carried out some tests on the Sprague line at Lafayette (Ind.), where power was supplied by a slow-speed Hamilton-Corliss engine, and he worked out the average commercial efficiency of the system at the low figure of 25 per cent. In the present article the average efficiency of a Thomson-Houston line at Syracuse, New York, where power is obtained from Armington and Sims engines, came out at 37 per cent., the station efficiency being 62·8 per cent., as against 40·7 per cent. at Lafayette. As the length of the lines is not very different and the number of cars running at the time of the tests was the same, the results would appear fairly comparable. It should be mentioned, however, that the Lafayette line contains far more curves and gradients. An average efficiency of 37 per cent. is certainly a great advance upon one of 25 per cent., but electrical engineers are not likely to rest content until a much higher figure is attained. Large motors geared direct to the axle will doubtless come into general use in due time, and may be expected to give better results than any we have to show at present. One cause of the low efficiency of electric street railways has, however, we think been somewhat overlooked. We refer to the smallness of the number of cars usually run. When there are lines at work with 50 to 100 cars in operation, we may reasonably look for a higher efficiency than is obtainable on small lines, where the demand for power is continually varying from zero to maximum, in a manner which is scarcely conducive to high efficiency.

The efficiency of electrical railways also forms the subject of a leading article in the *Engineer* of last week; and, taking the results of some tests on the Manhattan Elevated Railway, a very poor case is made out, and electrical traction is found to compare very unfavourably with propulsion by steam. We have some diffidence in criticising the opinions expressed by our contemporary, since it is a recognised authority on railway matters, and we are fully aware that the electrical engineer who proposes to go into the subject of traction has much to learn from railway practice. We should, however, never think of taking an American test as a source of information as to what is the utmost possible in the matter of efficiency. We all know that there are hundreds of miles of electric lines in daily work in the United States; but, from what we hear, they are designed and carried out in much the same style as the electric lighting. Mr. Addenbrooke's Paper is fresh in the minds of most of our readers; and they will doubtless remember the candid way in which excuse was there made for rough-and-ready work. Such work, most visitors to the States admit, would not be tolerated here for a day; but since it satisfies our friends on the other side, it is no part of our business to offer criticisms. On these grounds, even if "the efficiency of the entire plant was 15·1 and the average loss was 84·9 per cent.," we should not be prepared to pronounce that the case was an utterly bad one; but if Messrs. Mather and Platt do not do twice as well as this in the Subway, we shall be surprised.

Without going into the definition of the "success" of any engineering enterprise, we think that the term is yet more ambiguous than our contemporary seems to suggest. In many respects "steam locomotives comply with all the demands which are made on them, so far as doing their duty is concerned;" but the day has come when we want a locomotive which shall be lighter than the whole of the rest of the train which it draws, and a steam generator which can be designed without regard to bulk or weight. In tramway work we admit that the main question is the cost per car-mile compared with horse-traction; but the reduction of the weight of the rolling stock by 60 per cent. or more, with the consequent lighting of the permanent way, and facilities for such lines as that which is being built at Liverpool, and the absence of vitiated and sulphurous air, are questions which will hold their own in spite of even a higher cost for working. Admitting that "there is a certain speed for a motor at which its efficiency is a maximum, and at all other speeds its efficiency decreases," the increased torque at starting, with a heavy current, is clearly comparable to the large steam consumption when the links are notched down, as is pointed out in the report on the tests, and is not altogether a weak point in electrical traction.

A method of electrical welding has been brought out by a Mr. Coffin, of Detroit, which, although put forward as something new, is practically only a development of the process of Dr. Bernados, which was described in *The Electrician* of November 25th, 1887, Vol. XX., p. 58. The method has none of the admirable automatic properties of the Thomson electric welding system, and merely employs the radiant heat of the arc for heating the metal; the advantage being, as was stated in our description of the Bernados process, that the heat is taken to the place required, instead of having to bring the metal to the forge. Mr. Coffin in some cases uses two arcs between two pairs of carbons arranged one on each side of the pieces to be welded. The only novelty in the account of his methods of welding is the localising of the current by means of a powerful magnetic field concentrated in the required direction.

A second Paper has been published by Messrs. Herzog and Stark, of Buda-Pesth, on the theoretical predetermination of current distribution in a network of electrical conductors, and the authors have favoured us with a translation of it. In the midst of diagrams of imaginary conductors and series equations and determinants, we find that among other results they arrive at the conclusion that "several concentrated loads or a distributed one between any two neighbouring nodal points may be reduced to one concentrated load equal to the algebraical sum of these loads, and tapped from the common centre of gravity." Whether these calculations are of interest to pure mathematicians, we cannot say; but we had some little doubt as to their practical value to the engineer who has to design and arrange mains for the distribution of electrical energy in towns from central stations. To satisfy ourselves, however, on this point, we submitted the Paper to an engineer who is engaged in this very work for one of the principal supply companies in London, and we were not surprised to learn that such theoretical investigations are of no use in practice.

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EVEN the work of Prof. FORBES, though it served a good purpose at the time, is of comparatively little service in the daily work of one who has to arrange such matters for actual execution. One result of Prof. FORBES' Paper at all events was to show that distribution over considerable areas by a simple low-tension service was hopeless, and his memorable copper conductor (28 metres wide and 1 centimetre thick), to carry 70,000 amperes, which was warranted not to warm the pavement more than 10° centigrade, probably contributed to the development of alternate current and other methods of distribution at high pressure.

THE calculations of the Hungarian authors are amplifications of those bewildering "relations" of KIRCHOFF which we happened to select as a subject for study when first beginning to unlearn the early electrical science acquired from the works of Prof. PEPPER and Dr. LARDNER.

THE West Coast of America Telegraph Company held a meeting, with closed doors, on Monday last. It was, however, an open secret that Sir JOHN PENDER was appealed to to do his best to help the Company in the way of negotiation, so as to avert the effects of the threatened competition. It is understood that Mr. MARSHALL, the Chairman of the Company, is to interview Sir JOHN PENDER to obtain his opinion, so as to bring about a better state of affairs. The shareholders were well pleased with the suggestion that Sir JOHN'S assistance and advice should be obtained.

THE present issue of *The Electrician* contains a steel-plate portrait of Dr. OLIVER LODGE. The portrait has been engraved from a fine photograph taken by Maull and Fox, of Piccadilly.

Electric Traction in Spain.—Electric tramways are to be opened between Bilbao and Santurce, and between Barcelona and Sarria.

Submarine Cable Extensions.—The telegraph steamer "Amber" has arrived at Zanzibar with the Zanzibar—Dar-es-Salaam—Bagamoyo cable on board.

Melbourne.—According to *The Times* correspondent the streets of Melbourne are partially lighted by electricity, owing to the failure of the gas supply consequent upon the gas-stokers' strike.

Edinburgh.—At the last meeting of the Town Council a report by the Lord Provost's Committee, "recommending notice of meeting to resolve to take action under the Electric Lighting Acts," was adopted.

Porsonal.—The future address of Mr. Arthur C. Cockburn (late manager of the Acme Electric Works) will be 22, Streatley-road, Brondesbury, where he will practise as a Consulting Electrical Engineer.

The "Electrical World."—The National Electric Light Association issue of the *Electrical World* of New York consisted of 98 pages, and is claimed as the largest number of an electrical journal that has ever been issued.

The Vienna-Brunne Telephone Line.—This line is to be opened during the present month. According to the *Elektrotechnische Zeitschrift*, an extension of the line from Brünn through Iglau to Prague is projected.

The Popp System in Hanover.—Dr. O. Gusinde, who was engaged to report on the adoption of the Popp compressed air system for the distribution of power in this town, has expressed his opinion in favour of the distribution being effected by electricity.

Weybridge.—The Chertsey Rural Sanitary Authority have given their consent to the granting of a Provisional Order by the Board of Trade, to authorise the supply of electricity in Weybridge by the Laing, Wharton and Down Construction Syndicate.

Strike at the Westinghouse Works at Pittsburgh.—The strike of the Westinghouse Electric Company's, Pittsburgh, employés, determined upon at a previous meeting, went into effect on August 11th. Both plants are shut down, and about 1,200 men are idle. The men demand shorter hours.

The Telephone on the Congo.—The steamship "Ville de Maranaho," which recently left Antwerp for the West of Africa, had on board all the necessary material for a telephone line which is to be run along the Congo railway. The wires are to be of phosphore bronze, and the Dejongh telephone will be employed.

The Telephonic Transmission of Music in Berlin.—An experiment was made on Tuesday last in transmitting operatic music by telephone from the Opera-house to the Urania Theatre of Science. It was a complete success. It is hoped in Berlin that it will be possible to make an arrangement with the telephone exchanges to furnish other places with music through the telephone.

Lewes.—An offer has been received from the Gülcher (new) Electric Light and Power Company to undertake the lighting of the streets of this town. It is proposed to use 240 16-candle power incandescent lamps, to be distributed over seven and a half miles of streets. The Company undertake to start the running within 16 weeks of the receipt of order. The present gas contract terminates at Christmas.

Railway Rates.—The Board of Trade have been unable to come to an agreement with any of the six Railway Companies on whose classification and schedule of maximum rates reports have been presented to Parliament; and they will therefore employ the time before next Session in considering any facts and figures which may be laid before them, before embodying in a Provisional Order the classification and schedule which they think ought to be adopted.

Glasgow.—It is expected that active steps will very shortly be taken for putting in operation the provisions of the Glasgow Electric Lighting Provisional Order. It has not yet been determined by the Glasgow Corporation whether the Provisional Order shall be administered by the Gas Committee, or by a Special Committee appointed for the purpose. It is urged by some that the administration of the terms of the Order would be safer in the hands of a Committee elected for the purpose than in those of the Gas Committee.

The Late M. Lucien Gaulard.—A bas-relief in honour of the late M. Lucien Gaulard was recently inaugurated at Larrzo, a small town 30 miles away from Turin. This "acte de justice réparatrice," as it is termed by *La Lumière Electrique*, is due to the initiative of Prof. Alexandre Volta. The following inscription is engraved in gold letters beneath the bas relief: "Here in the year 1884 Lucien Gaulard, of Paris, overcame, for the first time, by means of alternating currents, the difficulties of transmitting electric energy to long distances."

The Copper Market.—According to Messrs. H. R. Merton, there has been an increase in the deliveries of 537 tons for the month of August, compared with July, while the total supplies in England and France are now no more than 9,393 tons, against 11,470 tons in the previous month. Stocks have therefore declined over 2,000 tons, and now stand at the comparatively low figure of 69,959, as compared with 106,000 tons at this time a year ago. The price of copper has now risen to £60. 10s., or about the highest point touched since the collapse of the French syndicate last year.

The Currie Automatic Switch for Accumulators.—In this switch the scum which is produced on the surface of the electrolyte of an accumulator towards the termination of a charge is made use of. Two pieces of metal are arranged one over the other, just above the level of the liquid, in circuit with a battery, an alarm bell, and a switch actuated by an electromagnet. When the cells are well charged the accumulation of scum on the surface of the electrolyte completes the circuit

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between the two strips of metal, which rings the bell and switches the cells out of the charging circuit.

The Effect of the Electric Light upon the Consumption of Gas.—At the recent meeting of the Congrès de la Société Technique du Gaz at Lyons, M. Le Roy produced some figures showing the effect of electric lighting upon the consumption of gas in France and abroad. The figures obtained, however, related only to 23 towns, 6 of which had no central lighting-station, 13 had central stations competing with the gasworks, and in 4 the Gas Companies also worked the electrical supply systems. The increase in the gas consumption during the past four years was 24·1 per cent. in the first instance, 13·85 per cent. in the second, and 16·5 per cent. in the third. From these figures it would seem that from the Gas Companies' point of view the next best thing to having no central lighting-stations is to run them themselves.

Birmingham.—The laying of the electric light mains is now being vigorously carried on by the Birmingham Electric Supply Company. The feeding mains are of bare copper strip, strained up and resting on glass insulators fixed in concrete culverts under the footways. The distributing mains are of insulated cables, laid in cast-iron troughs, and surrounded with bitumen. It is intended to charge 8d. per unit; the Company having power under their provisional order to charge 10d. per unit. Among the buildings which the Company have already arranged to supply are the Victoria Law Courts, the Grand Hotel, Colmore-row, and the branch Bank of England, Temple-row. In the Victoria Courts provision is being made for about 700 lights, and in the Grand Hotel for 200. In all these cases the internal work is being done by the Company.

City and Guilds of London Institute.—The programme of technological examinations of the Institute and of its associated Colleges covers a very wide range of subjects, the majority of them relating to different trades. Certificates are given both in ordinary grades, and with honours. Candidates for the former have to pass at least the elementary stage of the Science and Art Department's examination; and for the latter an examination in geometry, physics, and chemistry. In Electricity there are three sets of examinations, viz., Telegraphy, Electric Lighting and Transmission of Power, and Electrical Instrument Making, the examiners being Mr. Preece and Dr. J. A. Fleming. The examination papers, which are given in full, indicate that the teaching is thorough, though the training which can be given by the registered teachers in various parts of the country must be of a very different character to that of the Central and the Finsbury branches.

Telegraphy during the Commune.—One of the first things to be done after the recent disastrous fire at the New York offices of the Western Union Company was to re-establish the identity of each of the maze of wires running into the premises. Experienced electricians being on the spot, the task was not a very difficult one, and in a single day 300 circuits were restored. The ease with which this work was carried out at New York recalls to our mind, says *La Lumière Electrique*, a very instructive historic incident which occurred during the Commune. When the Republican Government quitted Paris, the operators at the central office in the Rue Grenelle managed to mix up all the wires before leaving. The Communists were so ignorant of everything connected with telegraphy, that it was beyond their powers to unravel the wires; and during the whole time that they were in possession of the building, namely, from the end of March to the end of May, they were only able to use the military lines. M. Fabre de Lagrange, who was forced to accept the appointment of chief electrician to the Commune, took good care to keep the wires in confusion; and, amongst other services to the State, he sent misleading telegrams, and thus saved many public and private buildings which the rebels wished to blow up by using an explosive mixture of air and coal-gas. These facts were clearly authenticated by the Court-martial which tried M. Lagrange, and he was honourably acquitted.

The Electric Lighting of ss. "Normannia."—The most recent contribution to the fleet of Atlantic racers is named the "Normannia," the gross tonnage of which is 8,500 tons, and which is owned by the Hamburg-American Steam Packet Company. The "Normannia" lighted throughout with the electric light by Messrs. Siemens and Halske, of Berlin; the London firm of Messrs. Siemens Bros. and Co. having done all the fitting up. There are four 36 kilowatt (100 volts × 360 amperes) dynamos. As the total number of lamps in the ship is only 1,100 of 25 candle-power, and as each dynamo is capable of supplying 600 lamps, only two of the four need be kept running. Each dynamo is coupled direct to a high-speed engine, making 360 revolutions per minute, and developing 50 brake horse-power. Steam is supplied from the main boilers at a working pressure of 160lb. to the square inch. The lamps are by the Edison-Swan Company, and are of frosted glass. In the decorated parts of the ship they are fixed in brass holders of roses and lilies, and in some cases little reflecting globes are fitted up in the semblance of buds. On the deck and at suitable places there are groups of three lamps with large concave reflectors and a glass framing in front. In the well above the saloon there is an electrolier with a large number of lamps, making an effective illumination. There are a number of portable lamps in the engine and boiler rooms, and portable reflector lamps for the stokehold. The skin of the ship is used as the return.

The Trouvé Electric Erygmatoscope.—At a recent meeting of the Académie des Sciences, M. G. Trouvé described an electrical appliance devised by him to facilitate the inspection of the geological strata pierced by the boring tool. The apparatus consists of a powerful incandescent lamp enclosed in a cylinder. One of the hemicylindrical surfaces of this cylinder constitutes the reflector; whilst the other, which is of thick glass, allows the luminous rays to pass through it, and light up the successive strata through which the lamp descends. At the base of the instrument there is an elliptical mirror, while the top is open, so as to enable an observer placed at the head of the boring and armed with suitable glasses to see on the mirror the reflected image of the stratum illuminated by the lamp, which is arranged so that its upward rays are intercepted. The whole apparatus is suspended from a cable formed by the two conducting wires. This cable is wound on a drum, the trunnions of which are insulated from one another and connected to the leads, current being obtained by two rubbing contacts attached to the poles of a portable battery. This arrangement enables the instrument to be raised and lowered without difficulty and without interrupting the observations. The erygmatoscope as at present arranged gives excellent results down to a depth of over 600 feet, and with a more powerful lamp it could be used at still greater depths. An expedition which has been sent out to the Mozambique coast by the Portuguese Government, to search for coal beds and other mineral deposits has been supplied with erygmatoscopes.

Atmospheric Electricity.—In a Paper recently read before the Vienna Academy, Herren Elster and Geitel give the results of a year and a-half's observations of atmospheric electricity on the north side of Wolfenbüttel (bordering an extensive meadow). They used a stand carrying a petroleum flame, and connected by insulated wire with an electroscope. A marked difference was found in the phenomena of spring, summer, and autumn, on the one hand, and winter on the other. It appears to the authors that other factors than humidity, with which Exner seeks to explain the variations, are concerned in the case. When the temperature goes below zero, cold mist being then generally present, there is often rather a sharp rise in the values, the aqueous vapour having then less action. Rainfall in a neighbouring region lowers the fall of potential both in winter and summer, and a disturbance of the normal course will announce a coming change in places still unclouded. Snow, it seems, rather raises the values. It has been shown by Linss that the course of the fall of potential is inversely as the coefficient of dispersion of the air for electricity; which, again, depends not only on the dust and aqueous vapour present, but also, according to Arrhenius's theory, on a sort of electrolytic or dissociative action of the sun's rays on the atmosphere (thus it has been shown that electricity escapes from a conductor under the influence of ultra-violet rays). The authors find their results support this latter view. They consider that the electric processes during formation of precipitates are the chief cause of the disturbance of the normal condition.

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The Maintenance of High-Tension Circuits.—In an interesting article in the *Western Electrician*, Mr. Alex. Dow remarks:—"There are few new circuits these days which do not give a perfect test when first completed. The attainment of high insulation is an everyday occurrence. Its maintenance for many days under ordinary conditions of operation is rare. Look to your lineman," says Mr. Dow. "What shall it profit if the insulation be one megohm per mile for 99ft. between poles, and the last 6in. of each stretch be split and ruined by a too tightly-twisted tie-wire? The moral is, that after a good wire is selected, it must be well strung and well jointed. Another consideration is the insulation of supports. The glass insulator is about as satisfactory a support, mechanically and electrically, as can be devised; especially if it be of the double petticoat pattern. Those who have had experience with long telegraph lines know that the shape of the insulator has much to do with the insulation resistance; and the adoption of the double petticoat shape by the British Government Telegraph Department is a strong endorsement of its advantages. Porcelain knobs are not fit for high-tension work. Their enamel cracks, and they absorb moisture. Their shape is convenient sometimes, but glass insulators of the same shape can be had, and are much superior. The glass is usually the last insulation of the circuit. This need not be, for the pin and cross-arm which support it are wood, and dry wood is a very good insulation. Buy unpainted pins and arms, dry them, and paint them thoroughly with the paint used for joints. Troubles will come while there remain with us bad weather, and telephone men, and the total depravity of inanimate things; but the troubles that are due to bad construction, and the ordinary wear and tear, and causes that may be foreseen, should disappear for ever."

Street Railway Amenities.—The "mule line" at Springfield (Ill.) has, it appears, been trying to hold valuable franchises without giving the people any service, and there has been a strong opposition to this policy, which recently culminated in an open struggle. According to a correspondent of the *Western Electrician*, the Citizens' Company, known as "The Mule Line," has a franchise to extend its track, but has not taken advantage of it, and its operations generally have been unsatisfactory. At one o'clock one Sunday morning the Electric Street Railway Company set a large force of men to work laying a track on Spring-street, past the end of the Citizens' track, so as to get ahead of them, and capture the Spring-street line. They had only three rails laid when they were stopped by the Mayor and a posse of police force. The Electric Company claimed the privilege under a State charter of laying tracks anywhere in the city. The Mayor was obdurate, and refused to let them proceed until the Council gave them permission. The Electric Company kept its men on the ground all night. At 1 o'clock on the following day the President of the mule line, at the head of a force of men, attempted to lay a track parallel to that of the Electric Company. They came to blows, but the fight was stopped by the police. Then the citizens took a hand, and, throwing off their coats, laid about a block and a half of the Electric Company's track, and the police did not interfere. While all the police force was busy on Spring-street preserving order, the President of the Electric Street Railway Company took a large force of men and laid about 2,000 feet of track on South Grand-avenue, two miles away, where the mule line had another charter track it would not use. The police did not find this out until about seven o'clock in the morning. The whole police force, says this correspondent, in conclusion, has been watching the 300 men the car companies have employed.

The History of Electric Tanning.—In a recent article in *La Lumière Electrique*, M. Rigaut says: "Like all other discoveries and inventions, that of using electricity in tanning is not a new one. About 1850, a currier named Crosse, invented an apparatus to utilise what he called the 'effects of electricity or galvanism for tanning purposes.' Two electrodes were placed in a tan-pit, one made of lead, the other of zinc. The pit was then filled with water and skins, and, after an interval of three days, tan was added in small proportions, in order to concentrate the liquor. Ten years later, an Englishman named Ward, of Lancashire, made a series of experiments. Instead of electrolysing the skins in water before adding the tan, he used electricity in the tanning baths. At Paris, in 1861, a M. Rebu invented a system of electric tannage. This is said to have been very complicated. The skins were treated with carbonic acid and hydraulic pressure; and then submitted to the action of salts of lime, of magnesia, and of iron. Currents of electricity were passed through the skins while they were immersed in the above mixtures and the usual tanning solutions. In 1874 M. de Mertens tried another system. At the bottom of a large vat was placed a layer of carbon, connected with the positive pole of a dynamo. On this skins covered with tan were placed. On the top of this heap a plate of zinc was placed, connected to the negative pole. The vat being filled with tanning liquid, the current was passed through. M. Mertens' system has been employed in nearly 600 pits for some years past at a tanyard in the environs of St. Petersburg, and by it about thirty-five days is required to tan the skins. In 1876, Gaulard and Kresser brought out another process, and in 1883 skins tanned by Gaulard's process were exhibited in England. In 1887, in Sweden, Messrs. Abom and Landin brought out a method for the use of electricity, and this has been in operation for two years at Noorköping, in Sweden, with good results, forty-five days being required for tanning. Some months before this Messrs. Worms and Balé, at Paris, had worked a process for the rapid tanning of skins by the aid of the electric current.

A Statue to Gay-Lussac.—At Limoges, on the 11th inst., a statue of Gay-Lussac was unveiled before the Minister of Commerce and the Association Scientifique de France. It may not be out of place, remarks *La Lumière Electrique*, to call attention to the fact that this illustrious member of the Académie des Sciences played a somewhat important part in the history of electrical science at the commencement of the century. As is generally known, he gained considerable renown by his balloon ascent of 1804. He started from the Conservatoire des Arts et Métiers, and attained an altitude of 7,000 metres (23,100ft.). This celebrated ascent was undertaken to test the assertion made by Robertson, the aeronaut, in a communication to the Société Galvanique de Paris, that the magnetic force of the earth greatly diminished at a short distance from its surface. Gay-Lussac's observations were held to have definitely disproved Robertson's statements. It should be mentioned, however, that the methods of observation employed by the celebrated physicist were of such a rudimentary character that his results would probably not have been considered conclusive but for the fact that they agreed with what seemed probable having regard to the smallness of the altitude compared with the radius of the earth. To test Robertson's statements it was necessary to go up as high as he did. A few days previous to the successful ascent, Gay-Lussac, accompanied by Biot, had failed to attain the necessary altitude, and the latter, therefore, gave up the idea of accompanying his colleague. Biot accepted Gay-Lussac's conclusions without hesitation, and manifested no wish to emulate his exploit. As to Gay-Lussac he never again set foot in the car of a balloon. When Napoleon I. heard of the achievements of Davy's battery he expressed a desire to have one like it in France, Gay-Lussac therefore undertook the construction of the well-known battery at the École Polytechnique. Together with Thénard he repeated the experiment of decomposing the alkaline bodies, and it was in the course of this work that some potassium injured his eyes, rendering him blind for a month, until Dupuytren took him in hand and restored his sight. The various experiments carried out by means of this battery were described in the first volume of the new memoirs of the Société Philomatique, under the title of "Etudes sur le Pouvoir Chimique de la Pile." During the last years of the first Empire and during the days of the Restoration, Gay-Lussac was editor of the *Annales de Chimie*. He was head of the committee engaged in investigating questions connected with lightning conductors, and the subject of atmospheric electricity occupied his attention from time to time. He did not believe that electricity was generated either by the evaporation or condensation of vapour; for him, clouds were simply conductors on which atmospheric electricity accumulated. He travelled through Italy with Humboldt, and studied the magnetic phenomena of the peninsula, as well as the electricity of the torpedo-fish and of dry batteries. Gay-Lussac died in 1850, just at the dawn of the electric telegraph.

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PROF. OLIVER LODGE, F.R.S.

The subject of our sketch was born in 1851 at Penkhull, a village near the Staffordshire Potteries. At the age of eight he was sent to Newport (Salop) Grammar School, where he was thoroughly grounded in the old-fashioned manner, and with the aid of constant corporal punishment, in the rudiments of Latin, Greek, and Mathematics. At fourteen he was put into business with his father in the Potteries, and remained there for six or seven years. During this time he informs us that he made his first acquaintance with science by reading an odd monthly number of the *English Mechanic*, and afterwards picking up what he could from the articles of the "Penny Cyclopædia." Later, while on a visit to London, he heard a course of six lectures on Heat by Tyndall at Jermyn-street, and also attended a private course on elementary chemistry. He then began to attend evening classes in chemistry under the Science and Art Department at the Wedgwood Institute, Burslem; and in 1872 was permitted a winter's course at the South Kensington Chemical Laboratory, on the annual examination list of which he came out bracketed first.

In 1871, by working at odd hours, he matriculated at the University of London, and after two years of private study passed the Intermediate Examination for a Science degree, having failed in Botany at the first trial. In this examination he obtained honours in Chemistry and Physics, standing alone in the first class in the latter subject. He next tried for a scholarship at St. John's College, Cambridge; but, not succeeding in getting nearer than *proxime accessit*, he went to study mathematics at University College, London, where Prof. Carey Foster enabled him to live without much home aid by teaching in exercise classes. In 1875 he took his B.Sc. degree; and the post of Demonstrator of Physics at University College was created and offered to him about the same time. In the same year he published, in conjunction with Prof. Foster, several Papers on the flow of electricity in a plane conductor, in which the forms of the lines of flow and equipotential lines are found practically and mathematically for various shapes of conductor, and for different positions of the electrodes.

It was during a holiday visit to Heidelberg in 1876 that he read and analysed the first volume of Maxwell's Electricity, and the same year he exhibited before the British Association a model, consisting of a string on which are threaded, either loosely or rigidly, balls attached by elastic bands to fixed supports. The various parts of the model each represent some electric property, and its purpose was "to illustrate mechanically the passage of electricity through metals, electrolytes, and dielectrics, according to Maxwell's theory." It is now well known to every reader of "Modern Views of Electricity;" and it showed very clearly the charge and oscillatory discharge of a Leyden jar, though at that time the meaning of the inertia of the balls was not known; indeed, Dr. Lodge says in a note at the end of his communication on the subject (*Phil. Mag.*, 1876) that after reading Thomson's paper on oscillatory discharge he does not understand his constant, "the electrodynamic capacity of the discharger." In the same note he frankly confessed that he had not then read the second volume of Maxwell. In those pre-telephone days how little was known to ordinary people about self-induction! With this exception the views of Dr. Lodge on this subject were almost as advanced 14 years ago as they are to-day, and his subsequent work in this department has been directed towards investigating the nature and insisting upon the importance of self-induction.

In June, 1877, he published a paper describing a modification of Mance's method for measuring battery resistance, in which a condenser and galvanometer are used in place of the ordinary Wheatstone's bridge galvanometer. Later in the year appeared his suggestion for a standard Daniell cell, in which the copper sulphate solution is prevented from getting to the zinc rod either (1) by having to diffuse through a very long column of zinc sulphate; or (2), by connecting the two liquids by a fine capillary layer of sulphate of zinc. In the same year he took his degree of Doctor of Science, choosing Experimental Electricity as his special subject. In the autumn of 1877 he became Assistant Professor of Physics at University College, and undertook lecturing duties. He was also Lecturer in Physics at Bedford College, London. Afterwards, in addition to these appointments, he assisted the late Prof. W. K. Clifford in the Mathematical Department of University College.

During this period two other events of importance took place. The first of these was his marriage in 1877. The other was the appearance in Chambers's Series of a treatise by Dr. Lodge on "Elementary Mechanics." Since its first publication this book has had a very successful sale, having run through several editions.

The original work of this period was an extended series of observations on the thermal conductivity of metals and crystals. The first researches had for their object the determination of the absolute conductivity of crystals and rare substances. The method was to insert a piece of the crystal, cut into the shape of a short circular cylinder with parallel faces, between the ends of two similar bars of metal, the further ends of which were maintained at 100° C. and 0° C. respectively. The curve of temperature along each bar was noted. The conductivity of tourmaline was determined in this way. The same apparatus, using only one bar of metal, was afterwards used in an investigation into the change of thermal conductivity with temperature in the case of metals; but the results obtained were somewhat uncertain, owing to the want of constancy in the amount of radiation from the surface of the bar. Dr. Lodge had a new and larger apparatus made for the same purpose in 1885, and some work was done with it, but the subject is by no means exhausted, and it is to be hoped that he will some day return to it, considering the close relation which exists between the coefficients of electrical and thermal conductivities of metals.

In November, 1879, Dr. Lodge undertook the measurement of the resistance of some alloys of copper and tin made by Prof. Chandler Roberts (now Roberts-Austen). The results showed that sudden changes in resistance occur even for small changes in the percentage composition of the alloy; and there are well-marked maxima and minima of resistance corresponding to definite chemical compounds. For example—Sn Cu_4 has a minimum of conductivity.

About this time the telephone and the Hughes Induction Balance came into prominence, and directed the attention of physicists more closely to the phenomena of self and mutual induction. Moreover, the article of Chrystal in the "Encyclopædia Britannica" shed a clear light on the subject, and obtained many new readers for the hitherto uncut pages of the second volume of Maxwell. Amongst other things, it led Dr. Lodge to publish a mathematical theory of intermittent currents and the induction balance. The facts observed by Hughes were here accounted for and somewhat extended. The effects of making and breaking a circuit were also discussed more fully than in Chrystal's article. But possibly the greatest value of the Paper lay in the fact that it familiarised students with the nature and action of self and mutual induction in closed circuits.

In 1881 Dr. Lodge was elected to the Professorship of Physics and Mathematics at the new University College in Liverpool, and entered upon his duties by an inaugural address delivered in October of that year, the subject being "The Spread of Education." During the greater part of the College Session 1881-2 his time was occupied in superintending the construction and equipment of the Physical Laboratory. In addition to this he delivered all the courses of lectures both in Physics and Mathematics. At the end of a year the chair of Mathematics was endowed, and Prof. Lodge was thus relieved of this part of his onerous task, retaining the Professorship of Physics, which he still holds. He then commenced a series of experiments to ascertain the behaviour under different circumstances of secondary cells with plates of various materials and with different liquids, and acted as scientific adviser to the Electrical Power Storage Company during the two years, 1884-86, following their early days of difficulty and discouragement. In 1884 he took out a patent for the use of mercury sulphate along with zinc negatives in secondary cells. He likewise

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found among other things that plates of zinc and peroxide of lead in sulphuric acid gave a steady electromotive force of about 2·5 volts, the highest which he could obtain from any single practicable cell. He proved experimentally that the reason of the sudden drop in the E.M.F. of ordinary secondary cells was the scumming over of the negative plate with sulphate of lead.

In September, 1882, he found time to contribute his quota to a discussion then occupying the columns of the *Philosophical Magazine* regarding English and German views of the dimensions of a magnetic pole in the electrostatic system of units. Prof. Clausius had introduced some confusion by ignoring the dimensions of the magnetic constant; Prof. Lodge, along with others of the Maxwell school, insisted on the retention of the permeability factor.

In the spring of 1883, Prof. Lodge secured the friendly co-operation of the late Mr. J. W. Clark as demonstrator; and in 1884 published, in conjunction with him, a classical Paper on the behaviour of dusty air near illuminated bodies. This communication bears the melancholy words "Part I." on its title-page. The second part has been delayed, possibly altogether lost, by the untimely death of Mr. Clark, whose loss Dr. Lodge felt very deeply.

The British Association meeting at Montreal in 1884 was a very busy time for him. He was chosen to deliver one of the evening discourses, and took for his subject "Dust." In addition to this, he was one of the secretaries of Section A, and also opened the first formal discussion ever held in that Section. The discussion was "On the Seat of Electromotive Force in the Voltaic Cell." The controversy on this point had been raging for almost the whole of the century, and the subject was very eagerly debated on both sides. Prof. Lodge found himself entertaining views almost diametrically opposite to those of such authorities as Sir William Thomson. He consoled himself, however, by the conviction that Maxwell, had he been alive, would have supported him. The discussion was followed a little later by a Paper from Prof. Lodge on energy paths in voltaic circuits, showing how Poynting's views really settled the question completely. After the success of the 1884 discussion Dr. Lodge established his reputation as a controversialist, and was asked to open a discussion on Electrolysis at the next (Aberdeen) meeting of the Association. In it he reviewed the state of electrolytic theories up to that date, and after the discussion took up the subject with a view to obtaining data for the rate of migration of ions in electrolysis. Indeed, during the years 1886-7 his experimental work was mainly devoted to the subject of electrolysis. In these two years a considerable portion of his time was taken up by the duties of the Electrolysis Committee, of which he was (and still is) a Secretary. For the 1886 Report he translated and reviewed several foreign memoirs on the subject.

In the autumn of 1887 Prof. Lodge began his researches on waves in conductors and on Leyden jar discharges. The first experiments were described in the Dr. Mann Lectures, which were delivered before the Society of Arts in March, 1888. Since that time his experiments have proved that pulses travel along isolated wires with the velocity of light, and he has investigated the conditions indicated by theory and perfectly borne out by fact, under which an electrical discharge is oscillatory in character, and has shown that the case of a lightning discharge may, and in general does, satisfy those conditions. He has always emphasised the fact, first clearly published by Heaviside in these columns, that oscillatory discharges or impulsive rushes tend to keep to the outside of a conductor, and his most recent communication on the subject was mainly directed to showing how a closed conductor may be used to afford protection from a lightning flash to telegraphic installations.

The interest of these experiments was greatly increased by the discussion at the British Association at Bath in 1888 on Lightning Conductors, in which Prof. Lodge again took a leading part.

The researches just mentioned refer mostly to waves in metallic conductors; but the simultaneous and overlapping work of Hertz on the propagation of electric waves through dielectrics has been eagerly followed by Dr. Lodge. All Hertz's experiments have been repeated at Liverpool, and about Easter of last year two pitch lenses were cast in order to verify that the laws of refraction of these waves are the same as those of visible light. Since then Prof. Lodge has attempted to account for the action of the eye by supposing transverse oscillations to take place in the rods and cones; and he has even gone so far as to construct an artificial "electric eye" to illustrate his views. Oscillators for producing electric waves have been made by him of all shapes and sizes, giving waves from 1 inch to 2,000 miles in length. Indeed, during the past three years the lecture theatre of the College at Liverpool has constantly been adorned either by a maze of wires for the Leyden jar discharge experiments, or by these oscillators and their corresponding resonators; a notable feature being the large oscillator with its plates each 4ft. square and 12ft. apart, suspended in mid-air. At the end of 1887 Prof. Lodge published in *Nature* his views on the ether theory, and the mechanics of the propagation of light and electricity. These articles were collected into a book, and issued in the *Nature* series in 1889, under the title "Modern Views of Electricity."

Some further idea can be got of his activity from the fact that Prof. Lodge delivers on an average ten or twelve lectures weekly during eight months of the year; but this is not all. He is member of the Council and of the Library and Building Committees of the College, and in the case of an institution growing so rapidly as that at Liverpool, these take up a considerable amount of time. He is also one of the Examiners in Sound, Light, and Heat for the Government Science and Art Examinations, and has just been elected an Examiner in Physics at the University of London, having previously (1876-79) held the post of Assistant Examiner. As Professor at one of the three constituent Colleges he is also an Examiner for Victoria University. In 1885 he was one of the jurors at the International Inventions Exhibition, and wrote for the official handbook a short article on progress in electricity during the past 25 years.

In the spring of 1888 the University of St. Andrews conferred upon him the honorary degree of LL.D., and shortly afterwards he was admitted a Fellow of the Royal Society. He has been a member of the Physical Society since 1875, and is now on the Council. He is also President of the newly-formed local Physical Society at Liverpool. In connection with the British Association, besides the offices already mentioned, he was one of the secretaries of Section A from 1878 to 1884, and has served on many committees. Prof. Lodge is also a Member of the Institute of Electrical Engineers. Moreover, he is interested in the subject of hypnotism, and has communicated papers at various times to the Society for Psychical Research, of whose Council he is a member.

In 1889 he applied his Leyden jar experiments to a measurement of the value of "v," the ratio between the electrostatic and electro-magnetic units of electricity, working in the Cavendish Laboratory, Cambridge, in conjunction with Mr. Glazebrook. The results of this research are not yet quite complete.

The clear terse way in which Dr. Lodge sets forth his ideas and describes his experiments has awakened in the minds of many an interest in his work which the ordinary theorist finds himself unable to create. This lucidity of statement contributes greatly to his success as a controversialist, while in his College lectures it is especially felt and appreciated. Moreover, it makes him welcome everywhere as a writer or lecturer on scientific subjects. In a stranger his fine physique and commanding presence possibly create a certain sense of awe; but this is quickly dispelled after coming into more intimate contact with him and experiencing the influence of his intense enthusiasm. To his assistants his unceasing thoughtfulness, kindness, and sympathy render him something more than a friend. The quality and quantity of his work serve to place him in the very foremost rank of the younger School of Physicists; and we sincerely hope that he may, for many years yet, take an active part in demonstrating the properties of that Ether which he has been so instrumental and successful in transferring from the realms of mathematical conception to the domain of actual physical fact.

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MAGNETISM IN IRON AND OTHER METALS.*—XXX.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 456.*)

§ 112. **Whitworth's Mild Steel.**—Figs. 82 and 83 give a corresponding selection of Hopkinson's results, for a specimen of mild steel contained 0·126 per cent. of carbon. Its critical

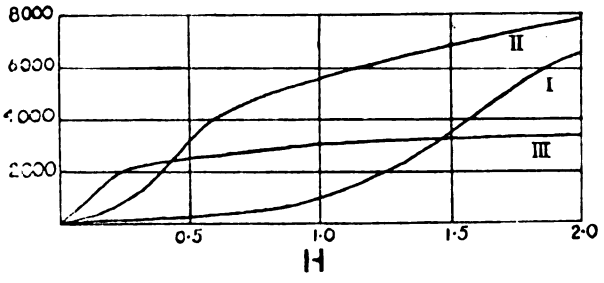

Fig. 82.—Magnetisation of Mild Steel at Various Temperatures.

temperature was 721°C., above which the permeability was only 1·12. The curves reproduced here correspond to the following temperatures:—Curve I., 12°C.; curve II., about 620°C.; curve III., about 715°C. It will be seen that these

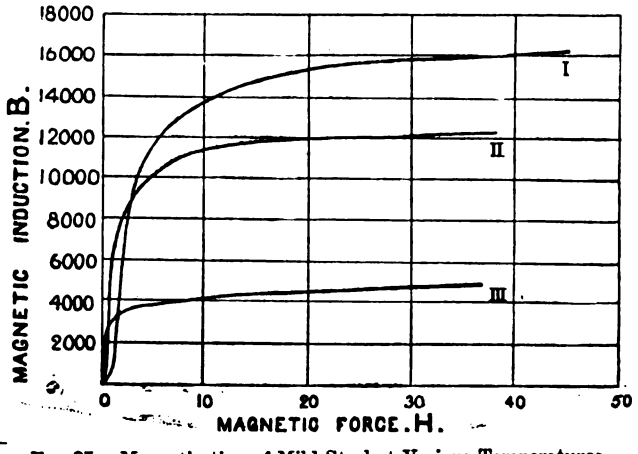

Fig. 83.—Magnetisation of Mild Steel at Various Temperatures.

present the same characteristics as the corresponding curves for iron. With a force of 0·3 the highest permeability is over 9,000, and this is found at a temperature only a very few degrees below the critical point.

§ 113. **Whitworth's Hard Steel.**—Fig. 84, taken from the same source, relates to a sample of hard steel containing 0·96

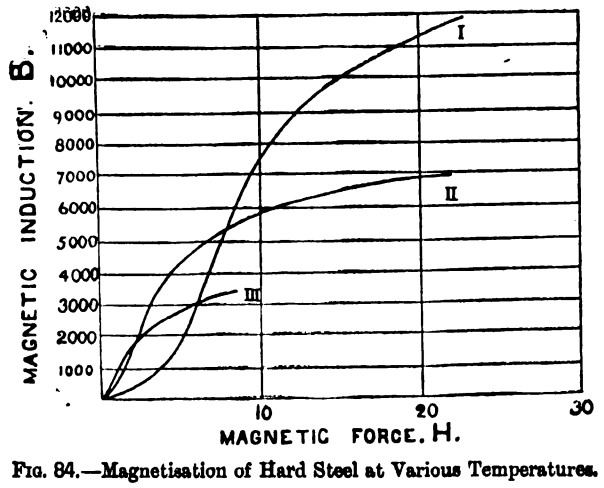

Fig. 84.—Magnetisation of Hard Steel at Various Temperatures.

per cent. of carbon. The sample was annealed before the observations were made. The three curves, I., II., and III.,

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are for three temperatures, 9°C., about 522°C., and about 678°C. respectively. Fig. 85 is the curve of μ and temperature for the same sample, the magnetising force being 1·5. The loss of magnetic quality at the critical temperature is scarcely so sudden as in wrought iron and mild steel, and the influence of heating is more uniformly distributed at lower temperatures; but the same general characteristics are again obvious.

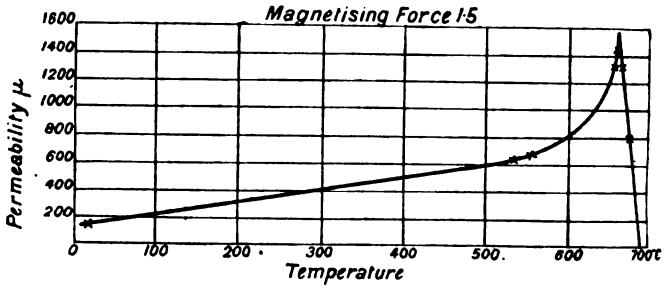

Fig. 85.—Relation of Permeability to Temperature in Hard Steel.

§ 114. **Hopkinson's Experiments with Nickel.**—In dealing with nickel, Hopkinson* has pursued the same method of experiment, using a ring, and finding, by the ballistic method, curves of magnetisation, while the ring was maintained at one or another of a series of temperatures which ranged up to the critical point at which magnetic susceptibility disappears. The specimen tested was impure, containing 95 per cent. of nickel, with about 1 per cent. (each) of iron, cobalt, and carbon, and 1½ per cent. of copper. Its critical point was about 310°C. A little below that temperature the susceptibility diminished very rapidly with rise of temperature, though there was no such excessively rapid loss of susceptibility as iron shows (under weak magnetising force) when the critical point is approached. At lower temperatures the susceptibility was observed to increase with rise of temperature when the magnetic force was low, but to decrease with rise of temperature when the magnetic force was high, in accordance with what has been already described as characteristic of the effects of temperature upon all the magnetic metals. Thus, taking curves of **B** or of **I** and **H** at any two temperatures (both well below the critical point) it is found with nickel, as with iron, that the curve for the lower temperature lies at first below and afterwards above the other. Figs. 86 and 87 give a selection of Hopkinson's curves. In Fig. 86 the curves of **B** and **H** are drawn for five temperatures: one is an ordinary atmospheric temperature, and the other four are high temperatures tending towards the critical point. At the first of these (245°C.) there is a marked gain of susceptibility for forces lying below 45 or 50; the whole group illustrates how the loss

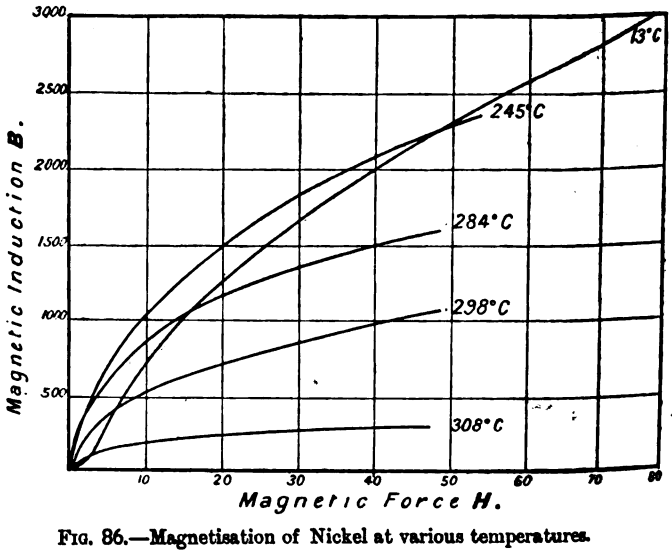

Fig. 86.—Magnetisation of Nickel at various temperatures.

of magnetic quality supervenes when the temperature is sufficiently raised.

* *Proc.* Roy. Soc., Vol. XLIV., 1888, p. 317.

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The same results are shown in a different manner in Fig. 87. There the induction B is represented as a function of the temperature—the induction, namely, that is reached when the metal is magnetised at constant temperature by the application of the force which is specified separately for each curve. These curves should be compared with the curves of μ and temperature which have been given for iron and steel (Figs.71—81, and 85.

The main points of difference in the magnetic behaviour of nickel and iron with respect to temperature are, that in nickel the effects of temperature, when the temperature is low, are more considerable than they are in iron; that in nickel the critical point is much lower; and that in nickel the change from the magnetic to the non-magnetic state is much less

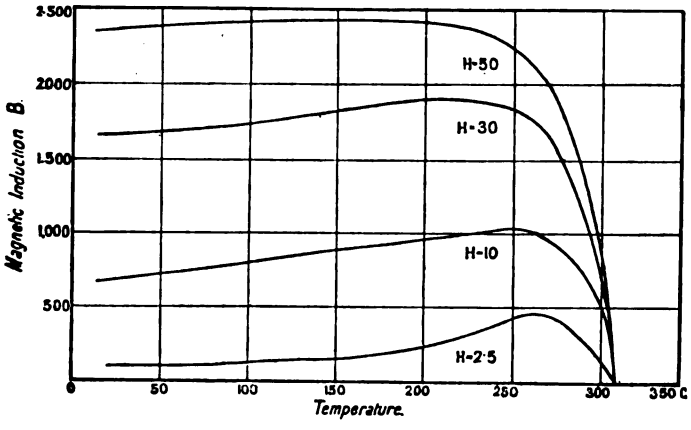

FIG. 87.—Magnetisation of Nickel at various temperatures.

abrupt than in iron. Perhaps for this reason the change is not associated with any such striking physical changes as accompany it in iron. Nickel does not recalesce, and an experiment of Hopkinson's* shows that the change from the non-magnetic to the magnetic state, as the metal cools, is attended by no sudden liberation or absorption of heat. Notwithstanding the fact that the specimen tested by Hopkinson was not pure the critical point found with it appears to be fairly representative of the critical point in nickel. In another sample tested by Du Bois†, the critical point again occurs about 300° C.

ON THE ELECTRO-DYNAMICS OF STATIONARY BODIES.‡

BY H. HERTZ.

(Continued from page 458.)

It will be noticed from the expression already given for the electro-magnetic energy that the quantities X. Y, Z, L, M, N have been defined in such a way as to have their physical dimensions the same for each. It follows from (1) and (2) that if we regard μ and ϵ as simple numbers, the quantity A is the inverse of a velocity. This quantity is, in fact, a constant of the ether itself, and does not depend on the existence of other bodies.

Multiply the equations given in (1) and (2), by L, M, N, X, Y, Z respectively, add them together, and multiply the resulting equation by $\frac{1}{4\pi A}\,d\tau$, when $d\tau$ is an element of volume. Integrate throughout a space bounded in any given manner, and let the normal to one of the surface elements, $d\omega$, make with the axes the angles (n,x), (n,y), (n,z). When the integration is performed, we obtain

$$\frac{d}{dt}\int\left\{\frac{\epsilon}{8\pi}(X^2+Y^2+Z^2)+\frac{\mu}{8\pi}(L^2+M^2+N^2)\right\}d\tau = \frac{1}{4\pi A}\int\begin{vmatrix}\cos(n,x) & \cos(n,y) & \cos(n,z)\\ X & Y & Z\\ L & M & N\end{vmatrix}d\omega \qquad (4)$$

This equation shows that the variation of the electro-magnetic energy contained in a given volume can be expressed in terms of quantities which only depend on the surface of the volume considered.

We may replace the quantities ϵ and μ by unity if we are considering the ether alone; and even for non-conductors the equations can be simplified by substituting for X, Y, Z, the quantities $X/\sqrt{\epsilon}$, $Y/\sqrt{\epsilon}$, $Z/\sqrt{\epsilon}$, and for L, M, N, the quantities $L/\sqrt{\mu}$, $M/\sqrt{\mu}$, $N/\sqrt{\mu}$, if at the same time we substitute $A\sqrt{\epsilon\mu}$ for A. The preceding reasoning has to be re-examined if we cannot suppose the body in question to be homogeneous; but investigation shows that, although for crystalline media the formulæ become much more complicated, the results arrived at are of the same general character.

Distribution of Electric Force in Good Conductors.—In those bodies which have been hitherto considered, every variation of electric force appears to be determined by the existence of magnetic force. If within a given space the magnetic force is zero, all cause capable of producing such disturbances disappears, and until magnetic perturbations penetrate within the region the electric forces remain constant. But this is not true of all bodies, for in a great number of substances electric forces when left to themselves diminish with more or less rapidity, and, in such cases, magnetic force is absolutely necessary to preserve the electric forces from variation. We shall call such substances good conductors. The most simple hypotheses we can make with regard to them are, that the diminution of electric force occurring in unit time is proportional to the strength of the force, and that the magnetic force tends to produce a variation independent of this loss, and equal to that taking place in connection with the bodies previously studied.

By the introduction of a new constant λ we can express the first hypothesis with regard to the component X of the electric force by the equation

$$A\epsilon\frac{dX}{dt} = -4\pi\lambda A X$$

The second hypothesis completes the first, and leads to the statement that a magnetic force exists whose variation takes place in accordance with the equation

$$A\epsilon\frac{dX}{dt} = \frac{dM}{dz}-\frac{dN}{dy}-4\pi\lambda A X$$

The constant λ may be called the specific electric conductivity of the body. Its dimensions are those of the inverse of a velocity. It follows that the quantity $\frac{\epsilon}{4\pi\lambda}$ is a time, that during which the electric forces when left to themselves diminish to a fraction $\frac{1}{e}$ of their former values, where e is the base of Napierian logarithms. We are thus led to the following equations, which are in perfect accordance with experiments:—

$$\left.\begin{aligned} A\epsilon\frac{dX}{dt} &= \frac{dM}{dz}-\frac{dN}{dy}-4\pi\lambda A X\\ A\epsilon\frac{dY}{dt} &= \frac{dN}{dx}-\frac{dL}{dz}-4\pi\lambda A Y\\ A\epsilon\frac{dZ}{dt} &= \frac{dL}{dy}-\frac{dM}{dx}-4\pi\lambda A Z\end{aligned}\right\} \quad \ldots\ldots\ldots (5)$$

These equations replace equations (2) which only hold true for non-conducting bodies. Equations (1), however, are true for both conductors and non-conductors.

If the body, instead of being homogeneous, is heterogeneous, a further modification must be made. If the properties of a body vary from point to point it is not true that electric forces allowed to subside naturally diminish till they ultimately vanish. The final value is constant, but not zero. It is independent of time, and is found greatest where the variation of chemical properties per unit length is most rapid. We shall modify our equations by supposing that the diminution occurring in electric forces abandoned to themselves is proportional, not to the absolute values of such forces, but to the excess of

* Hopkinson, *loc. cit.*, 319. † Du Bois, *Phil. Mag.*, April, 1890.

‡ An abstract of a paper published in the "Nachrichten von der Königlichen Gesellschaft, der Wissenschaften," for March, 1890; and reprinted in *La Lumière Électrique*, July, 1890.

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the absolute values over the final ones. Thus, if X', Y', and Z' be the final values of X, Y, and Z respectively, equations (5) become

$$\left.\begin{aligned} A\epsilon\frac{dX}{dt} &= \frac{dM}{dz} - \frac{dN}{dy} - 4\pi\lambda A(X - X') \\ A\epsilon\frac{dY}{dt} &= \frac{dN}{dx} - \frac{dL}{dz} - 4\pi\lambda A(Y - Y') \\ A\epsilon\frac{dZ}{dt} &= \frac{dL}{dy} - \frac{dM}{dx} - 4\pi\lambda A(Z - Z') \end{aligned}\right\} \quad \ldots \quad (6)$$

For crystalline conductors, the properties of which vary with direction, it cannot be assumed that when the electric forces are abandoned to subside naturally the rate of diminution of each component of electric force is proportional to the value of that component. We must assume it to be a linear function of the three components. Thus, equation (1) must be modified so that each left-hand member is replaced by a linear function of $\frac{dL}{dt}$, $\frac{dM}{dt}$, and $\frac{dN}{dt}$. A similar modification occurs with the left-hand member of equation (6), and also with the last term on the right-hand side.

Boundary Conditions.—It is easy to see that equations (1) and (6) (modified when necessary for crystalline conductors) may be made to represent all possible cases by a suitable choice of coefficients. If now we consider these coefficients as functions of the coordinates we may regard the surface of separation of two heterogeneous bodies as a space in which, although the coefficients vary with extreme rapidity, the equations are nevertheless fully applicable and should enable us to obtain the boundary conditions. In order to arrive at them in the simplest manner possible, let us suppose that the plane of x y coincides with the surface of one of the elements.

If there is no electromotive force between the bodies in contact we see, from consideration of (1) and (6), that the values of $\frac{dX}{dz}, \frac{dY}{dz}, \frac{dM}{dz}, \frac{dN}{dz}$ remain finite from one side of the boundary to the other. If we indicate by suffixes $_1$ and $_2$ the side of the boundary to which a quantity refers we have

$$Y_2 - Y_1 = 0 \qquad M_2 - M_1 = 0$$
$$X_2 - X_1 = 0 \qquad N_2 - N_1 = 0$$

Thus the tangential component of the force at the surface of separation remains constant.

We also deduce from the last equation of (1) and of (6) that the quantities

$$\mu\frac{dN}{dt} \text{ and } \epsilon\frac{dZ}{dt} + 4\pi\lambda Z$$

have the same values on each side of the surface. The reciprocal dependence of the normal components of the force on each side of the surface takes the form

$$\mu_1\frac{dN_1}{dt} = \mu_2\frac{dN_2}{dt}$$

$$\epsilon_1\frac{dZ_1}{dt} - \epsilon_2\frac{dZ_2}{dt} = -4\pi(\lambda_1 Z_1 - \lambda_2 Z_2).$$

If there is an electromotive force across the bounding surface, we may assume that the component Z' of the force normal to the surface is infinitely great in the bounding layer, but of such value that the integral $\int Z'\,dz$ across the layer preserves a finite value, whose amount we may determine without knowing anything about the way in which Z' changes. We shall satisfy these suppositions by making the hypothesis that the quantity $Z - Z'$ remains finite throughout the bounding layer, as also the quantities L, M, N, X and Y. The quantity Z is thus infinite, but we can still suppose that $\frac{dZ}{dt}$ remains finite. Thus from the last equation of (6) we obtain

$$\int Z\,dz = \int Z'\,dz = \phi,$$

and if we integrate with regard to Z the first two equations of (1) and of (6) across the bounding layer, we obtain the following conditions, since, owing to the infinite thinness of the layer, the integral of each finite quantity vanishes.

$$Y_2 - Y_1 = \frac{d\phi}{dy},$$

$$X_2 - X_1 = \frac{d\phi}{dx},$$

$$M_2 - M_1 = 0, \qquad L_2 - L_1 = 0.$$

These equations, in conjunction with the third equations of (1) and (6), show that the quantities

$$A\mu\frac{dN}{dt},$$

$$A\epsilon\frac{dZ}{dt} + 4\pi\lambda A(Z - Z'),$$

have the same value on both sides of the separating surface; so that by comparison with the expressions obtained when no electromotive force was acting, we see that if the material on both sides of the bounding surface is homogeneous, the existence of the electromotive force has no influence on the conditions which connect the forces acting on the two sides. If the material is crystalline the same line of reasoning can be pursued, and leads to expressions identical with the above, except that for N we must substitute a linear function of L, M, and N, and for Z a similar function of X, Y, and Z.

As the boundary conditions, after all, only consist of particular aspects of equations (1) and (6), we need not in future complicate matters by troubling about the modifications in our expressions necessary to represent what happens at the surface separating different media. If we sometimes neglect to give the proof that these modifications are quite determinate, it will not be because we judge such proof superfluous, but because the above example will serve as a model for obtaining it.

In what we have hitherto studied, each section has added to the number of facts embraced by the theory, and in this respect the following sections will exhibit a contrast; for they will not add to the fundamental facts, and their value will consist partly in a simpler manner of expression, and partly in the union which they will establish between our theory and old views on electrical science.

(To be concluded.)

TESTS OF ACCUMULATORS OF VARIOUS MAKERS.*

Although the results of numerous tests of the best known accumulators have been published, a series of tests carried out simultaneously on different accumulators for the purpose of effecting as close a comparison as possible between them is not without interest. The test carried out recently by M. R. Kopp, and described in *La Lumière Électrique*, related chiefly to accumulators made by the Oerlikon firm, the Huber accumulator made at Marly-le-Grand, the Julien accumulator made by the Société l'Électrique of Brussels, and the Tudor accumulators made by Busche and Müller, of Hagen (Westphalia). These tests were carried out at the Physical Laboratory at Zurich Polytechnic. In every case differences of potential were measured by means of a well-standardised high-resistance (20,000 ohms) Wiedemann galvanometer. The current was measured by means of a tangent galvanometer with an eccentric magnet. The resistance was calculated by the general formula $r = \frac{E - e}{I}$. As, however, the difference $E - e$ at the middle of the discharge was only a few hundredths of a volt, its value was somewhat uncertain. The charge was stopped when the E.M.F. ceased to sensibly increase, and the discharge was pushed until the E.M.F. fell to 1·85 volts.

The Oerlikon Accumulator.—Tests were made of three distinct types of cell: one of old design; one of new design, with gelatinous electrolyte; and another of new design, with the ordinary electrolyte.

The non-gelatinous accumulator contained seven positive and eight negative plates, 14·5 × 14·8 × ·6 cm. thick. The plates were placed in an ebonite box at a distance apart of about ·9 to 1 cm.

* Translation of an article in *L'Électricien* by M. G. Roux, being an abstract of an article in *La Lumière Électrique* by M. R. Kopp.

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This type of accumulator is used for the lighting of the trains between Zurich and Geneva. The weight of the plates is 14·4 kg., and that of the accumulator, when full, 20·4 kg. About ten preliminary charges and discharges were taken, and the accumulator was then overcharged and next discharged until the E.M.F. reached 1·9 volts. The density of the electrolyte varied from 1·17 to 1·25. The charging current was 14·5 amperes, and the discharging current 18 amperes.

Calling

Q_c the number of ampere hours put into the cell,
Q_d the number of ampere-hours taken out,
W_c the watt-hours $\int e_c I_c \, dt$ put in during the charge,
W_d the watt-hours $\int e_d I_d \, dt$ given out during discharge,
F_q the quantity efficiency,
F_w the energy efficiency,

we have the following results :—

Table I.

Number of test.	Q_c	Q_d	W_c	W_d	F_q	F_w
1	135·92	130·31	303·9	255·0	95·9	83·9
2	138·65	123·69	310·1	242·7	89·2	78·3
3	137·57	125·79	308·7	254·3	91·5	79·5

For some time the Oerlikon firm has been making gelatinous accumulators. The electrolyte consists of three volumes of acid having a density of 1·1, and of one to three volumes of silicate of sodium having a density of 1·2. The mixture is run into moulds and left for some time. It is then cut into slices of the requisite thickness and placed between the plates. It has been found necessary to keep this gelatinous mass wet by watering it from time to time.

An electrolyte of this kind has several advantages for traction work. It cannot be spilt, keeps the plugs in their places, and prevents short circuits. On the other hand, it has the inconveniences of retarding diffusion, thus increasing the resistance of the cell, especially at the end of the charge and discharge. Moreover, such an accumulator is quickly exhausted, and consequently its capacity is diminished.

The accumulator of the type C had the same dimensions as the previous one, but the plates were only 3 cm. thick. It contained 11 positive and 12 negative plates 6 cm. apart. The weight of the plates was 12 kg., and the total weight of the cell 18 kg. The normal rate of discharge of the cell was only 7 amperes, probably on account of the slowness of diffusion. The discharge was continued in this instance until E attained a value of 1·8 volts.

The results of the tests are given in Table II. :—

Table II.

Number of test.	Q_c	Q_d	W_c	W_d	F_q	F_w
1	112·76	94·15	244·82	176·5	83·5	72·1
2	112·66	94·73	244·79	177·7	84·1	72·6

If the rate of discharge was six or seven times greater, the efficiencies fell to 75·2 and 55·2 per cent. The resistance of the accumulator varied from ·003 to ·01 ohm.

The Huber Accumulator.—The Huber accumulator tested was of the portable type. Its plates were very thin, so that its capacity per kilogramme of plate was large. On the negative plates the square blocks of active material were pierced by circular holes 2 cm. in diameter, in order to increase the active surface. The dimensions of the plate were 15·5 × 16·7 × ·3 cm. The weight of the plates was 6·5 kg., and that of the accumulator complete 12 kg. The charging current was 12·5 amperes ; the discharging current 16 amperes. The results obtained are given in

Table III.

Number of test.	Q_c	Q_d	W_c	W_d	F_q	F_w
1	89·49	84·97	202·63	168·56	95	83
2	92·58	84·34	213·46	165·70	91	77
3	91·68	81·56	208·75	162·88	89	77
4	81·98	77·99	183·93	155·12	95	84

The resistance of the accumulator varied from ·003 to ·006 ohm, and the density of the liquid from 1·19 to 1·126. In other tests, when the discharge was pushed to the end instead of stopping at 1·85 volts, the efficiency was not diminished.

The Julien Accumulator.—The box of the accumulator tested was of wood, lined with lead. The seven positive and eight negative plates measured 23 × 18·5 × ·4 cm. They weighed 20 kg., the complete accumulator weighing 33 kg. The charging current was 24 amperes, and the discharge 28 amperes. The results obtained are given in Table IV.

Table IV.

Number of test.	Q_c	Q_d	W_c	W_d	F_q	F_w
1	251·6	224·7	570·8	445·5	89·3	78·0
2	247·9	225·5	562·2	446·8	90·9	79·5
3	250·7	230·9	572·0	450·4	92·1	80·3
4	247·5	226·7	555·1	447·7	91·6	80·7
5	248·9	223·7	551·9	447·5	89·9	81·1
6	246·4	229·2	560·3	445·5	93·0	81·4

The resistance of the accumulator varied from ·001 to ·002 ohm, and the density of the solution from 1·24 to 1·15.

The Tudor Accumulator.—The type of accumulator tested was intended for stationary work, consequently the plates were very thick. There were five positives and four negatives, measuring 16 × 19 cm ; the thickness of the negatives being ·7 cm., and that of the positives 1·6 cm. The weight of the plates was 25 kg., that of the cell complete 38·9 kg. The accumulators had been in use for several years, and the distance between the plates was sufficient to permit the plugs to fall freely to the bottom without danger of short-circuiting. The results of the tests carried out with this accumulator are given in Table V.

Table V.

Number of test.	Q_c	Q_d	W_c	W_d	F_q	F_w
1	98·05	92·29	214·07	179·10	94·1	83·7
2	100·10	86·15	218·56	168·42	86·0	77·0
3	91·34	84·65	197·20	164·35	92·7	83·3
4	93·84	86·95	205·63	171·78	92·6	83·5

The resistance of the cell varied from ·002 to ·003 ohm, and the density of the solution from 1·2 to 1·15.

Table VI.

Systems.	Useful capacity in ampere-hours.	Useful work in watt-hours.	Quantity efficiency per cent.	Energy efficiency per cent.	Weight of plates in kilogrammes.	Weight of accumulators in kilogrammes.	Useful capacity per kilogramme of plate.	Useful energy per kilogramme of plate.	Useful capacity per kg. of useful weight.	Useful energy per kg. of useful weight.	Total weight per h.p. hour.
Oerlikon accumulator, liquid electrolyte	126·6	250·6	92·2	80·6	14·4	20·4	8·8	17·4	6·2	12·3	59·8
Gelatinous electrolyte	94·4	177·1	83·8	72·4	12·0	18·0	7·9	14·8	5·2	9·8	75·1
Huber accumulator.	82·2	163·1	92·5	80·7	6·5	12·0	12·7	25·1	6·9	13·5	54·5
Julien accumulator.	226·8	448·7	90·9	80·2	20·0	33·0	11·3	22·4	6·9	13·6	54·1
Tudor accumulator.	85·8	168·0	92·6	83·7	25·0	39·0	3·4	6·7	2·2	4·3	171·2

In Table VI. is given a comparison of the accumulators under consideration. The Tudor accumulator being, as mentioned before, intended for stationary work, does not compare favourably with the rest. It is much to be regretted that M. Kopp did not indicate the useful capacity per square decimetre of *active service*, as this would have been a much more interesting factor than the capacity per kilogramme of active material.

The Peral Submarine Torpedo Boat.—The Spanish Government, says *Industries*, will soon publish the official report of the Naval Commissioners appointed to report on the trials of this submarine vessel lately made in Cadiz Bay. It seems that the report, though drawn up in very flattering terms for Lieutenant Peral, nevertheless recommends the Government not to construct any vessel of this class, as the trials have proved that the vessel is unseaworthy, and that it does not offer the conditions required for submarine navigation, even on coasts and in fine weather.

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ELECTRIC LIGHT AND HEALTH.

In giving a *résumé* of the arguments for and against the supply of electrical energy by Local Authorities in his recent lecture at Brighton, Mr. PREECE certainly dealt impartially with the question although he felt himself compelled to begin with an expression of admiration of our "Grandmotherly Government," on the ground that cleanliness of dwellings, drainage of towns, removal of filth and of nuisance, purity of good water and air, have been controlled in a truly parental manner by Acts of Parliament. We do not propose to discuss in these columns the knotty question as to what extent domestic legislation is to be desired; but we would remark *en passant* that in all these examples the function of the State or of the Local Authority has been to ameliorate matters by the suppression of noxious elements, rather than by any new introduction, development, or supply, such as that of electrical energy. It is one thing to define the minimum quantity of deleterious impurities with which the gas companies may pollute the air we breathe, to say nothing of the carbonic acid, which amounts for each burner to the exhalations of ten persons. It is quite another to engage in purveying electric current. Whatever may have been the causes which have conduced to the carrying out of hygienic provisions and the enforcement of sanitary principles by the Home Office and the Local Government Board, it is hardly to be imagined that any Local Authority, among the many

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that have applied for Orders, has been moved to do so by any regard for sweetness.

The arguments and figures given last week before the Sanitary Institute are interesting and not without value in themselves, but we can hardly hope that they will assist the development of electric lighting, since so little practical interest is taken in sanitary matters by the general public. The success of the Health Exhibition was not due to those who went to study patent traps and to examine new ventilators. Door-scrapers are more common than filters, though the cleansing effects of the latter are of greater importance than the obtrusively visible results of the former. While many people who would not hesitate to spend a hundred pounds in re-arranging the drains of a house prefer a gas burner to a pair of candles in their bedrooms, we can hardly expect that statistics about products of combustion will have much effect. Anything short of actual illness, whether it be due to bad atmosphere or errors of diet, receives but little attention. Several years ago Mr. Crompton drew a touching picture of the beneficial effects of electric light in the nursery; but it is difficult to induce people to realize the noxious influence of unseen mischief-working agents, such as microbes or carbonic acid. The serious amount of carbonic acid which is actually given off by gaslighting is due to the large amount of light which is commonly produced. Many people prefer to write by the light of two candles, and a similar illumination is considered sufficient for most dressing tables; but if gas is used a fourteen or sixteen candle burner is provided, often in an inconvenient position selected by the builder; and it is enclosed in a shade which cuts off from a quarter to half the light. The sulphur, sulphur compounds, and the unburned gas which are given off, are much more harmful than the simple carbonic acid, the amount of which given off by gas is, light for light, a little less than for sperm candles. An equally insanitary effect of gas is the great heat emitted both by radiation and as hot vitiated vapour-laden air. A glow lamp gives out, and as radiant heat alone, only one forty-seventh part of the heat given by a gas-burner of the same power.

The main question with the large majority of those who inquire about electric light is its price, as compared with that of gas. While we cannot at present see how a station on as large a scale as that at Deptford, and with an economy of production as great as that of the Kensington and Knightsbridge or the St. James and Pall Mall Company, can produce light from glow lamps to compete with gas at 2s. 3d. per thousand feet, we may be quite sure that we have not yet arrived at the finality which has been practically attained by gas. That industry, while it has by no means come to a standstill as regards new improvements, has reached a stage at which it is unlikely that any invention will be introduced which will reduce the price by two or three pence per thousand; but there is every probability that electric light will be cheapened to a considerably greater extent, even without any radical change in the efficiencies of lamps or in the systems of distribution.

But to return to the pros and cons from the sanitary point of view. Mr. Preece repeats a statement which he made some time ago as to the effect of electric light on the health of those who have to work in rooms where it is used. Since lighting by electricity has been introduced into the large and substantial building in Queen Victoria Street, which contains the chief offices of the Savings Bank Department of the Post Office, the extra work which has been done there, owing to the decreased number of absentees among the twelve hundred persons employed, has actually been sufficient to pay for the running expenses of the electric light, and a similar result has been observed at Liverpool and other places. The causes of ill health are generally invisible, but a result of this kind is of a very visible and objective character; and though it can only be distinctly recognised and quantitatively estimated in a thoroughly organized establishment such as that of a Post Office Department, it may be confidently asserted that it can be attained elsewhere by similar means.

We alluded recently to another tangible asset which may be credited to the electric light; and it is one which, as in the case of the Post Office *employés*, can be estimated in pounds, shillings, and pence, which appeal too often more eloquently to the employer than the pale cheeks and ailing of the workers. The absence of dirt and smoke, and the resulting decrease in the cost of redecoration, is very marked where the electric light replaces gas, even when the latter is carefully arranged. The cost of the pure light is so little greater than that of gas that the difference is amply made up by saving in renewals of decoration. Moreover now that we are aware of the enormous waste of energy which takes place in producing light, a great change will surely come before long, which may sweep away our modern dynamos. Though a glow lamp needs less than one twenty-seventh part of the energy required by an oil lamp giving an equal amount of light, and the arc light takes only a hundred and fifteenth part of that required by gaslight, the actual energy needed to set up the oscillations which we call light is vastly less. The day will come when, either by subjecting them to stewing and electrolysis after the manner of M. Dubois, which is described in another column, or by the patient watching of their habits and study of their mode of life by another Darwin, the glow-worm will be compelled to yield its secret, and the fire fly its mysterious economy, and we shall use the methods of these humble creatures who set the ether in vibration with so little apparent trouble.

NOTE ON THE USE OF SAUNDERS' CAPACITY KEY IN COMPARING CAPACITIES.

BY DR. ALEX. MUIRHEAD.

In *The Electrician* of June 20, page 170, an illustration and short description was given of Saunders' capacity key. This instrument is used in the following method of comparing condensers.

The method now generally adopted by telegraph engineers in comparing telegraph cables with condensers of known capacity was first published by Sir William Thomson in Vol. I. of the *Journal* of the Society of Telegraph Engineers, pages 397 and 398; and it may be considered as the converse of De Sauty's method of comparing the capacities of condensers by Bridge system (see page 379 of Sabine's "The Electric Telegraph," 1867). A description of the method will be found in the fourth edition of Kempe's Handbook of Electrical Testing, under the title of Gott's method, pages 339 and 340. The formula given by Kempe in connection with this method, viz., $F_1 = \frac{R_2}{R_1} F_2$. [$F_1$ and F_2 being the capacities of the two condensers compared, $\frac{R_1}{R_2}$ the ratio of the potentials to which they are charged respectively] is correct only when the balance of potential between F_1 and F_2 has been obtained immediately after the application of the battery and before the difference in the absorption of the two condensers has had time to take place.

That is to say: After making contact with battery, supposing the charging of the condensers in series to be instantaneous and the absorption *nil*, the formula would be correct, for there

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will then be an initial charge on each condenser of $Q = v\,F_1 = (V - v)\,F_2$, where v is the potential of the junction of the two condensers and V the full potential of the slides, Fig. 1.

$$\frac{V - v}{v} = \frac{R_2}{R_1} \therefore F_1 = \frac{R_2}{R_1} \cdot F_2.$$

Should there be, however, when condensers which differ in their rates of absorption are compared, any delay in obtaining a balance or reading on the slides, the potential of the junction of the condensers will vary, until at any instant it becomes, say, v_1, then, at that instant, the charges in the two condensers will be $(F_1 + f_1)\,v_1$ and $(F_2 + f_2)\,(V - v_1)$ respectively, where f_1 and f_2 are the apparent increase in the capacities due to absorption or soaking in of charge.

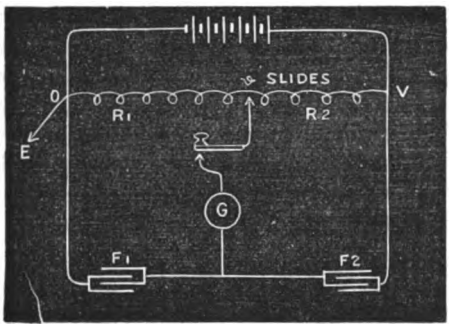

Fig. 1.

And on disconnecting the armature of F_2 from the slides and putting it to 0 or earth, its potential falls from V to 0, and immediately afterwards the potential of the junction of the condensers will be not 0, but, say, v_2; so that

$$F_1 v_1 - F_2 (V - v_1) = (F_1 + F_2)\,v_2.$$

Hence, $$(F_1 + F_2)\,v_1 - F_2 V = (F_1 + F_2)\,v_2;$$

or, $$(F_1 + F_2)\,(v_1 - v_2) = F_2 V;$$

or, $$\frac{F_1}{F_2} = \frac{V - (v_1 - v_2)}{v_1 - v_2}.$$

Therefore, in the above formula v_2 is the proper correction to make in order to reduce the observed v_1 to the true value at which it would have were there no absorption. It is necessary that v_2 should be measured at once before the oozing out of the charge absorbed by the dielectrics of the condensers begins, in which case $v_1 - v_2 = v$, otherwise it will slowly change and a wrong value will be obtained.

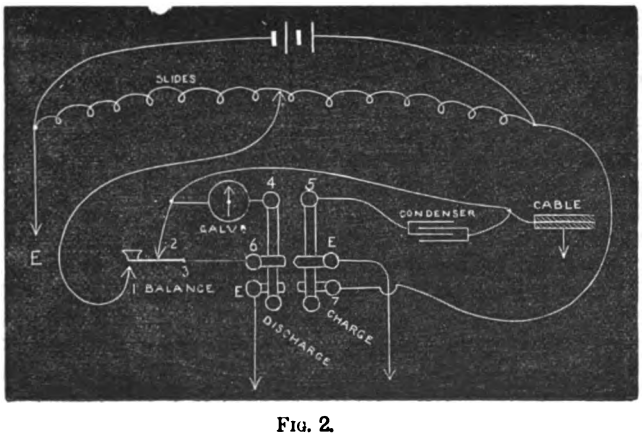

Fig. 2.

V and v_1 are known, and v_2, when a galvanometer is used, can be measured without delay in the following manner:—

As soon as v_1 has been observed, break the galvanometer circuit and shift the index of the slides down to zero quickly, then directly after bringing the armature of F_2 from potential V to zero, close the galvanometer circuit again, and observe the instantaneous throw α, which is a measure of v_2, the potential of the junction of F_1 and F_2. To get the value of v_2 from α, break the galvanometer circuit, and move the index of the slides up—say, 10 studs, again close the galvanometer circuit, and observe the throw β, then $v_2 = \frac{10\,\alpha}{\beta}$. If the throws α and β are in opposite directions, the equation given above is correct; if in the same direction it becomes

$$\frac{F_1}{F_2} = \frac{V - v_1 - v_2}{v_1 + v_2}$$

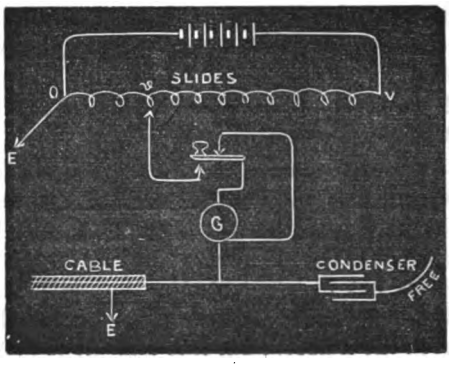

Fig. 3.

With the key designed by Mr. Saunders, Electrician-in-Chief of the Eastern Telegraph Company, all the operations described above in comparing capacities according to Sir William

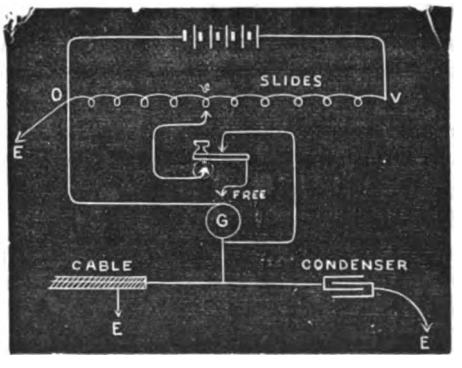

Fig 4.

Thomson's original method, can be quickly and effectively carried out. All the parts of the key are shown diagrammatically in Fig. 2, with the connections to slides, standard con-

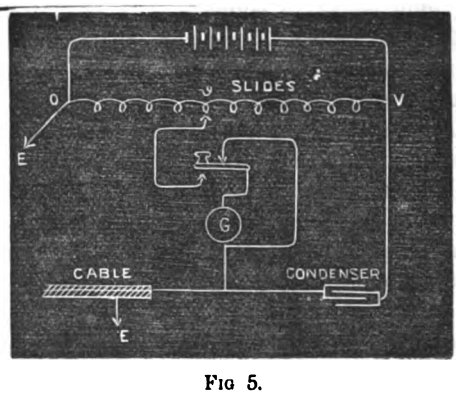

Fig 5.

denser, and cable, when joined up for capacity testing. When both levers of the key are "*up*" the connections are as shown in Fig. 3. Fig. 4 shows the connections when the lever marked "discharge" is "*down*," both cable and condenser being then to earth. On depressing the lever marked "charge," the condenser and cable are connected up in series to the battery and slides, as shown in Fig. 5. On depressing the "discharge" lever, the "charge" lever is automatically raised by means of the ebonite bar pivoted below the levers, which device is seen

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in the illustration of the key on p. 170. During the descent of the lever the connections are as shown in Fig. 6, removing the condenser from the slides and putting it to earth, and afterwards, as shown in Fig. 4, discharging both condenser and cable through the galvanometer to obtain the correction throw a.

To illustrate the importance of making a correction for absorption in the method above described, I give the following tables, taken from a report by Mr. Lilley, electrician on board the ss. Chiltern. Table I. is the result of a comparison of a mica condenser of ·3366 microfarad capacity against 1·4 knots of gutta-percha core at my laboratory; and Table II. of the

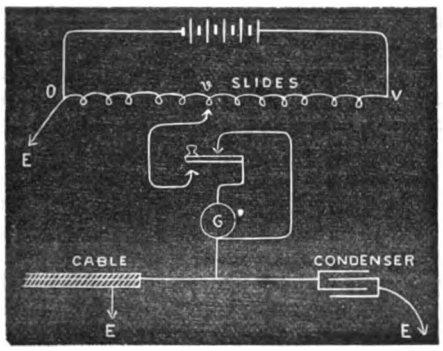

Fig. 6.

new Porthcurnow-Gibraltar cable against 60 microfarads of ordinary signalling condensers.

Table I.—*Condenser ·3366 mf.* versus *1·4 knots Gutta-Percha Core.*

Time of application of battery.	Slide reading.	Correction.	Slide reading corrected.	Apparent capacity.	Corrected capacity.	Per cent. difference between apparent and true capacity.	Per cent. difference between corrected and true capacity.
Seconds.							
67	5,853	91	5,762	·4750	·4576	4·144	·328
2·5	5,754	2	5,752	·4561	·4558	Nil	– ·043
25	5,803	63	5,740	·4654	·4531	2·039	– ·657
47	5,826	76	5,750	·4698	·4554	3·003	– ·153
230	6,080	293	5,787	·5220	·4623	14·447	1·359
110	6,014	285	5,729	·5078	·4515	11·335	– 1·008
82	5,863	106	5,757	·4770	·4567	4·363	·131
3	5,760	4	5,754	·4572	·4565	·235	Nil
4	5,764	8	5,756	·4580	·4565	·416	·087
5	5,768	12	5,756	·4587	·4565	·570	·087
6	5,772	12	5,760	·4595	·4574	·745	·285
7	5,772	10	5,762	·4595	·4576	·745	·328
8	5,774	11	5,763	·4599	·4578	·833	·372
9	5,776	11	5,765	·4602	·4582	·898	·460
10	5,780	13	5,767	·4610	·4585	1·074	·526
15	5,790	24	5,766	·4629	·4584	1·490	·504
Mean	5,822	...	5,759	·4693	·4570	2·65	·197

Temperature of condenser and core = 54° F.
True capacity of core, ·4561 mf.

Table II.—*Porthcurnow-Gibraltar Cable* versus *Condenser 59·94 mf.*

Time of application of battery.	Slide reading.	Correction.	Slide reading corrected.	Apparent capacity.	Corrected capacity.	Per cent. difference between apparent and true capacity.	Per cent. difference between corrected and true capacity.
Seconds.							
55	8,924	78	8,846	497·13	459·49	8·5 3	·288
35	8,890	46	8,844	480·07	458·58	4·780	·039
14	8,862	17	8,845	466·78	459·02	1·879	·185
2	8,845	0	8,845	459·02	459·02	·185	·185
2	8,845	0	8,845	459 02	459·02	·185	·185
Mean	8,873	...	8,845	472·4	459·02	3·106	·185

Temperature of condenser, 60° F. Temperature of cable, 3[illegible] F.
True capacity of cable, 458·17 mf.

NOTES ON HIGH VACUA.*

BY J. SWINBURNE.

I.

In a series of Papers on "Incandescent Lamp Manufacture" contributed to *The Electrician* in 1887, I called attention to the great superiority of the Geissler to the Sprengel form of mercury pump. Several kinds of Sprengel pump were successively connected to a Geissler, and both were worked at the same time. The Sprengel invariably stopped taking air down before the Geissler, in fact, the Geissler never stops. It acts as its own McLeod gauge, and never indicates a perfect vacuum. The probable reason why the merits of the Geissler have been so underrated is that it needs the greatest care in securing perfect dryness of the bulb and valve. Not only will traces of water vapour condense under the floating valve instead of lifting it and going through, but it is probable air does so too. About a century ago Davy showed that if the mercury were allowed to run up gently in an imperfect Torricellian vacuum, a bubble was left; but if allowed to rise suddenly, it indicated a perfect vacuum, the air being condensed against the glass. In the Lamp Papers I described a form of pump which avoids difficulties due to small condensations. The main bulb discharges into a small chamber sealed by a little V tube, so that a pressure of 1/100 A would move the mercury.

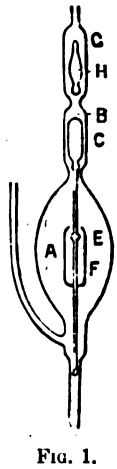

Fig. 1.

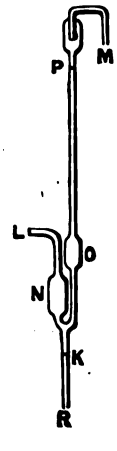

Fig. 2.

This chamber exhausts into a larger globe, exhausted mechanically, and sealed by a floating valve. The small chamber is thus as thoroughly exhausted as an ordinary pump can pump it; but the pump proper, exhausting into high vacuum, can thus work better. The condensed air and water cannot expand back into it. It is thus really a double pump, or two mercury pumps in series. The only drawback is that it needs some pressure to open the first valve or sealing, so that there might, after all, be some condensation under it. I have lately devised and used a pump made as follows:—A (see Fig. 1) is the body or chamber of the pump proper. This exhausts into the small chamber B, sealed by the valve C, and this exhausts into the chamber G, sealed by the floating valve H. G is connected to a reservoir and mechanical air-pump. The valve C has a long thin glass rod passing down through A into the lower tube, which acts as a guide. A loose sleeve, F, is strung on this rod. There is a swelling at E which fits the lower end of the sleeve, and is small enough to pass through the neck in putting the pump together. When the mercury rises in the globe A it lifts the sleeve till the lower end catches on E, which closes it. The mercury rises, and floats the sleeve, thus lifting the valve C. The mercury that sealed C then runs out, and there is a clear passage through into B; so no condensation takes place in A. The mercury rises till it floats H. When it falls, the valve C acts again, for the mercury has filled the sleeve F over the top, and C is heavy enough to sink the sleeve and rod when the sleeve is full of mercury. I have tried electro-magnetic and other arrangements; but this is the best as far as I have gone.

* Paper read before the British Association in Section A, Leeds, September, 1890.

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When using a pump it is best not to let air, and perhaps moisture, run through it more than can be helped. By the use of a sort of siphon it is possible to seal on new work to be exhausted without letting the air-pressure into the pump.

The point K (see Fig. 2) is the barometric height at which the mercury normally stands in the tube R. There is then a clear passage between L, which is connected to the tubes to be exhausted, and M, which goes to the drying tubes and pump. When a tube has been sealed off and a new one is to be put on, the mercury reservoir at the foot of the arrangement is raised so that the bulb N is filled. A tap at the foot of the tube R is closed and the vacuum in L is broken. The mercury then runs up to the new barometric height P. The new tube is then sealed on and exhausted by a mechanical pump, the connection being then sealed off. The mercury in the long tube then stands only half an inch or so above that in N, and on opening the tap at the foot of R, the communication is made again to the pump. The small bulb O, and the trap at the top are to prevent a plug of mercury from going round into the phosphoric tubes.

The pump is driven by water so as to be self-acting, and can be left running for any length of time. Those who have worked much with mercury pumps will realise the value of this. Nothing makes one feel the futility of life more than to exhaust something by hand which cracks at the last stage, when five hours of life have been ticked off.

II.

In the same Papers on Lamp Making I urged that the methods of measuring high vacua were inaccurate and completely misleading. The McLeod gauge and the induction coil are usually relied on for testing vacua. In incandescent lamp work the induction coil is almost exclusively used. With the test by induction sparks, I have, at present, nothing new to add, and will confine myself to the McLeod gauge. In measuring vacua with this gauge it is assumed that the mercury itself has no vapour tension. The vapour tension of mercury has been given by Regnault as about 50 millionths of an atmosphere. If it is anything like this, of course a vacuum of one millionth, or of ·005 millionth, as some experimenters profess to have reached, is absurd. When discussing this subject at the Society of Arts after Dr. S. P. Thompson's well-known Paper on "Mercury Pumps," Prof. Ramsay gave ·25 millionth of an atmosphere, or, as I shall write it shortly, ·25M. as the vapour tension of mercury at ordinary temperatures.

The whole action of a pump is consistent with a vapour tension of from 25 to 50M. A Geissler does not reduce the pressure in geometrical progression; but when it gets a good vacuum it takes out very little air each stroke, worked fast, and much more if worked slowly. This looks as if when the tension of mercury vapour was nearly reached, the air taken out at each stroke was what diffused into the mercury vapour. This would also explain why a Geissler, which goes on long after a Sprengel stops, does not so readily make a sparkless tube. A Sprengel stirs up the mercury, and gives the tube being exhausted more chances of getting filled with mercury vapour, which is a non-conductor. This also explains why so many experimenters get better vacua with hot mercury. Of course a new pump should be heated to get the moisture off the glass, but not when it is in ordinary use.

To test this more directly I attached two McLeod gauges to the same pump. They communicated till a fair vacuum was reached. One was then sealed by raising the mercury past the elbow tube. The gauges were allowed to communicate by lowering the mercury every now and then, and it was always lowered before taking a reading. By this arrangement, when the pressure was reduced nearly to the vapour pressure of mercury, one gauge might have little but mercury vapour, and show a good vacuum; while the other had air at the same pressure, and showed a pressure equal to the vapour tension of mercury, or nearly so. The gauges are graduated by finding $p\,v$ corresponding to one-millionth of an atmosphere, and graduating accordingly. The pressure in millionths is then the product of the reading on the closed tube and the difference in the column. Each reading is thus readily taken at several pressures to make sure there is no condensation of any vapours or gases. The readings obtained varied in an extraordinary way. When the exhaustion was carried so far that the open gauge registered 2M or 3M, the closed registered from 20M to 60M. The least difference in temperature seems to make a large difference in the readings. In some cases, when the vacuum was still low, the open gauge was heated till the mercury sputtered, and condensed about the bulb. The bulb was then warmed to evaporate the mercury and drive all the air out, and the elbow tube sealed by raising the mercury. When the gauge was cool both were unsealed and readings taken. The gauge that had been warmed sometimes gave 1M against no less than 230M in the other. Ten minutes' connection generally brought the readings equal. Obviously the movement of the air need not depend on diffusion only; for a very small difference of temperature would cause mercury to evaporate in one gauge and condense in the other, driving the air with it.

I made a gauge with an alloy of about equal parts of potassium and sodium, which is liquid at ordinary temperatures. It would, of course, absorb any mercury vapour, and has probably a low-vapour tension. It was very troublesome, for it could not be exposed to the air for a moment, and heavy hydrocarbons would prevent the pump's working. The alloy always gets some moisture, and gets coated with a thin film of oxide which prevents drops from uniting, and they can only be run together by heating under a hydrocarbon of low boiling point. I eventually got the gauge fitted up, but the alloy acted on the film of moisture on the glass, and the bubbles formed seemed to drive plugs of it about. It has a very low specific gravity, and pistons of it began to stray about inside the pump, and I was afraid they might get to the mercury, and by combining explosively, smash the pump, so the experiment was abandoned. In one experiment a plug of the alloy wandered into the mercury in R and cracked the tube.

Fusible alloy was next tried. It worked better, but the vapours of some sulphur that was used to trap any mercury vapour blackened the surface, and only two readings were obtained. These gave a pressure of only 13·5M as the vapour tension of mercury.

Whether it is really 13M or 50M is of comparatively little importance; but there seems to be quite enough evidence that the readings of ·01M and higher vacua that have been given are inaccurate to the extent of some hundreds of thousands per cent. This is important in many investigations pursued by means of mercury pumps, for instance, experiments on the "Fourth State of Matter." The question is also important in lamp making, as it shows that better vacua are possible, and they may be an advantage. I do not know whether pumps worked with alloy of sodium and potassium will come into commercial use.

ON A NEW METHOD AND DEPARTMENT OF CHEMICAL RESEARCH.*

BY DR. G. GORE, F.R.S.

Method of Working.

In an investigation "On the Change of Potential of a Voltaic Couple by Variation of Strength of its Liquid" (Roy. Soc. *Proc.*, 1888, XLIV., p. 296), I showed that by immersing a small pair of unamalgamated zinc and platinum plates in distilled water, then adding to the water successive small and equal quantities of a particular halogen, acid, or salt, until a more or less saturated solution was formed, and measuring by the method of balance with a galvanometer in the circuit, with a suitable thermo-electric pile (see *Proc.* Birm. Phil. Soc., IV., p. 130: also *The Electrician*, 1884, XII., p. 414), aided when necessary by a zinc-platinum distilled water-cell, or a Clark's standard cell, the change of electromotive force produced by each addition of substance, did not vary by a regular gradation. And I stated that "by plotting the quantities of dissolved substance as ordinates to the degrees of electromotive force as abscissæ, each substance or mixture of substances yielded a different curve of electromotive force on uniformly changing the degree of strength of its solution." And that "with a given voltaic couple at a given temperature, the

* Abstracted from the *Phil. Mag.*, May, 1890.

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Yours faithfully

Oliver J. Lodge

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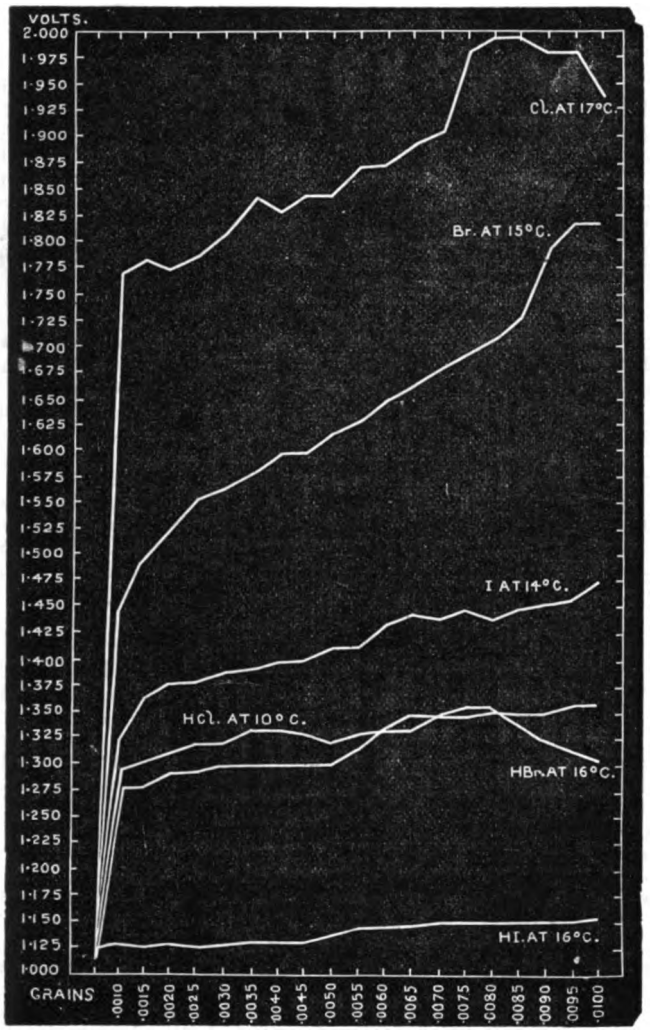

Fig. 1.

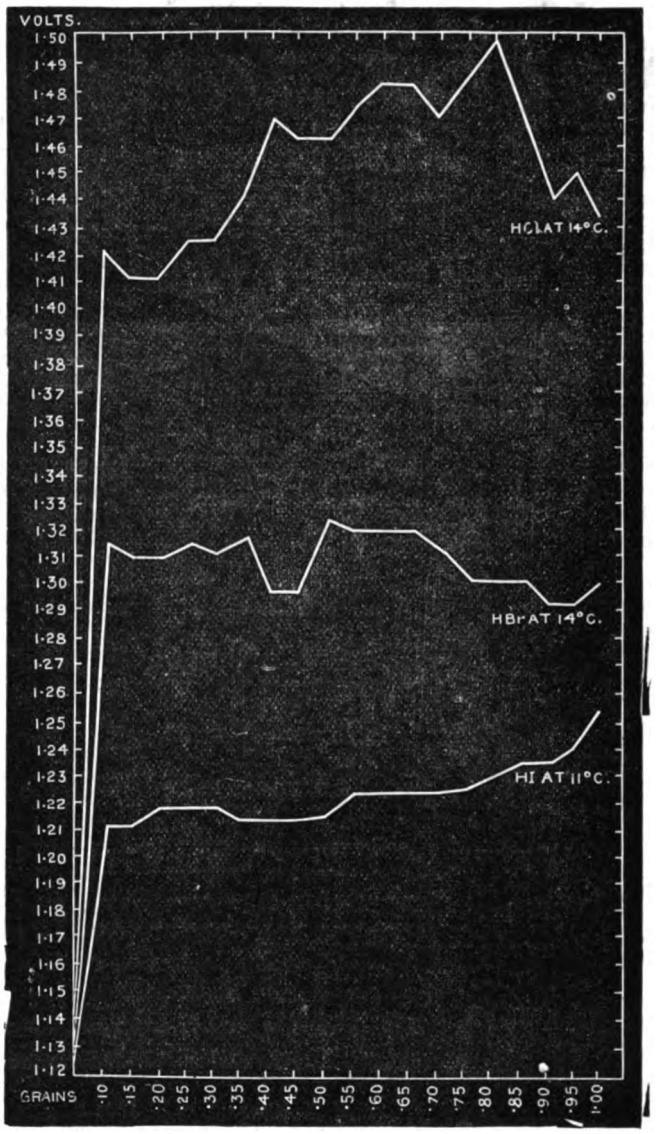

Fig.

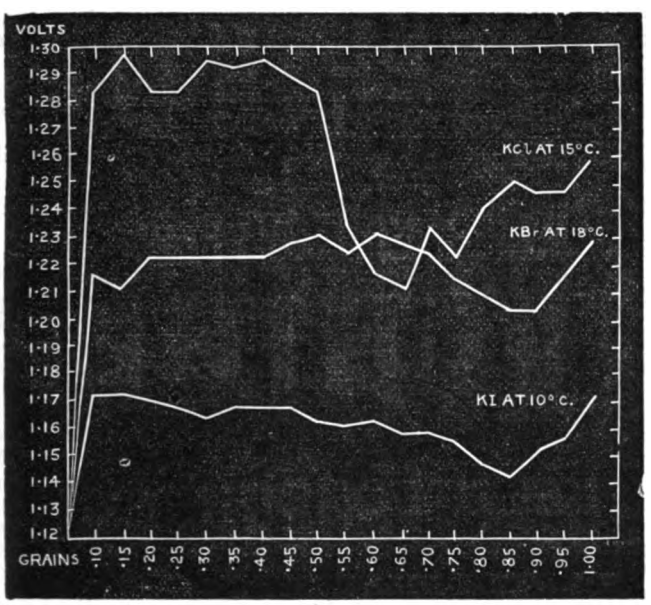

Fig. 3.

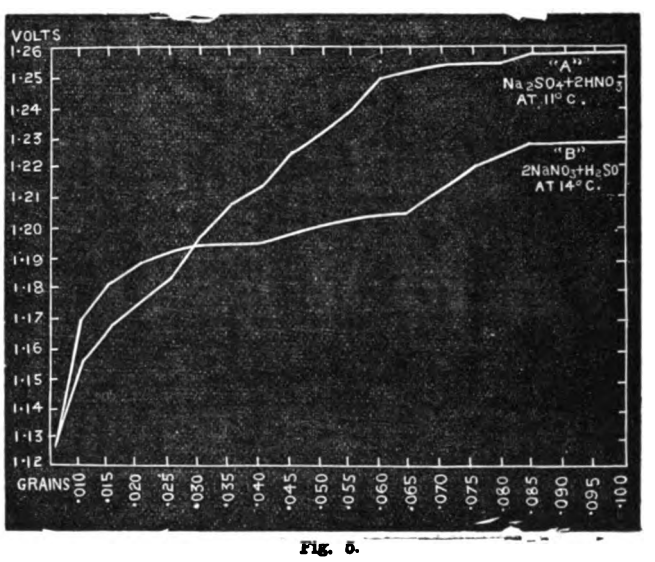

Fig. 5.

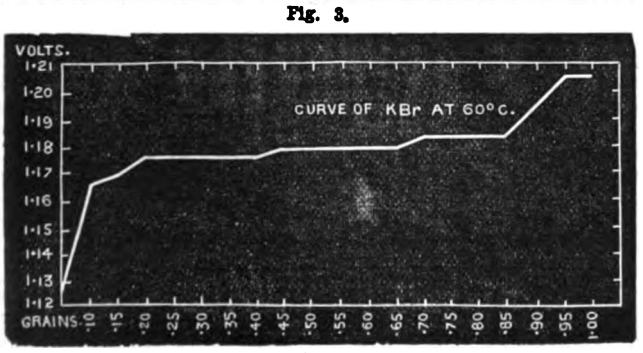

Fig. 4.

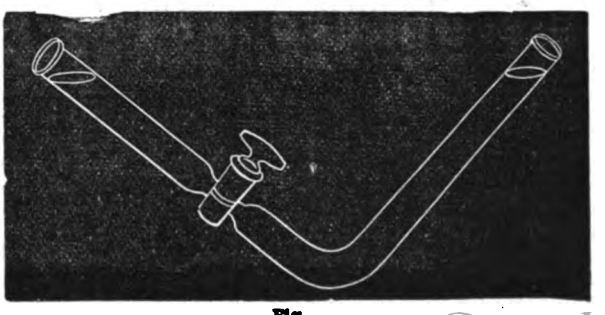

Fig.

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curve was constant and characteristic of the substance." The examples given in this Paper illustrate these statements, and the measurements were made by the above method.

Instead of employing a thermopile, the following plan with the "voltaic balance" might be adopted :—1st. Balance two small zinc-platinum voltaic cells with distilled water in each, and a galvanometer of 100 ohms resistance in the circuit, then add gradually sufficient of the exciting substance to one of the cells to just visibly upset the balance, and note the quantity added. 2nd. Balance the cells with a very weak solution containing one unit quantity of the substance in each cell ; then add a sufficient excess of the substance to one cell to again upset the balance, and note the amount of excess. 3rd. Balance the cells with a two-unit quantity solution, and upset the balance again in like manner. And so on through such a series of strengths of solution as may be desired to obtain a curve. The proportions of excess of substance added to the amount of water in the cell represent the relative amounts of voltaic energy of the different strengths of liquid.

This method is very much more sensitive than the one with the thermopile, for whilst the latter only divides the range of difference of potential between water and chlorine for example (= ·753 volt), in practical working into about 15,000 parts, the former divides it into 1,200 millions. On the other hand, whilst by the thermopile method the values of the unit of measurement are equal throughout a series, those of the numbers obtained by the voltaic-balance one vary with the degree of strength of the solution.

A. Curves obtained by Varying the Strength of the Solution at Both Metals.

Nearly all the measurements of electromotive force given in this Paper were made with highly pure substances, and in Section "A," with the exception of one instance only, each curve starts from the potential of unamalgamated zinc and platinum in distilled water at about 16° C. = 1·127 volt. The quantity of distilled water employed as the solvent was in nearly every case 155 grains, and the series of degrees of strength of the solutions of each substance were usually such as could best be worked by the process, *i.e.*, neither too strong nor too weak, and were with different substances either the same or so arranged as to best enable comparisons to be made between the results of the different series of measurements ; they were not always sufficiently strong to fully develop the most characteristic curves. For each separate measurement, with the solutions of the halogens and the strong ones of the acids, a fresh portion of the original liquid was taken ; with those of other substances the zinc was so feebly acted upon and the liquid so slightly altered in composition, that this was not found necessary. With solutions of salts, the presence of films of oxide upon the zinc was tested for by replacing the saline liquid by distilled water, and then observing whether the cell was still exactly balanced by a zinc-platinum water one. No trouble was experienced from polarization caused by hydrogen in the platinum plates, nor by atmospheric air dissolved in the water.

Curves of Chlorine, Bromine, and Iodine (Fig. 1).

The range of strength of the solutions of each substance was from ·001 to ·01 grain in 155 grains of water. With solutions of these substances the degree of electro-motive force increased somewhat with the period of immersion ; this difficulty was due to the great chemical energy of the substances, and was overcome by making the fluctuations of the galvanometer-needles equal on each side of zero.

Curves of HCl, HBr, *and* HI.

a. *Weak Solutions* (Fig. 1).

Each acid was pure and colourless. The solutions were of the same range of degrees of strength as those of the halogens, in order to compare the effects of the two groups of substances ; and the curves are all drawn on the scale of magnitude in each direction as those of the halogens.

Curves of HCl, HBr, *and* HI.

b. *Strong Solutions* (Fig. 2).

These solutions were one hundred times stronger than the previous ones in order to fit them for comparison with those of the corresponding salts ; they contained from ·10 to 1·0 grain of substance in 155 grains of water. The degrees of electromotive force of the solution of hydrochloric acid were variable, and those of the other two acids less so. These curves are drawn upon a scale 2·92 times as large vertically as those of the previous ones, in order to fit them for comparison with those of the corresponding salts ; the curves are more characteristic and present a much greater degree of irregularity of form ; this was a genuine effect, and was not due to temporary fluctuations of the current.

Curves of KCl, KBr, *and* KI (Fig. 3).

All the substances were highly pure, colourless, and inodorous ; the iodide was very faintly alkaline. The solutions were of the same range of degrees of strength as the strong ones of the corresponding acids, viz., from ·1 to 1·0 grain of substance in 155 grains of water. The electromotive force of the zinc-platinum couple increased somewhat with the period of immersion. The absence of solid films upon the zinc was proved by occasionally replacing the saline liquid by distilled water, and observing whether the cell was still exactly balanced by a zinc-platinum water one.

Curve of KBr *at* 60°C. (Fig. 4).

The range of degrees of strength of the solution in this case was the same as in the previous one, when the liquid was at 18°C., and was from ·10 to 1·0 grain of substance in 155 grains of water.

On comparing the two curves obtained at the two temperatures we find considerable differences, viz. :—1st. A great unlikeness of general form. 2nd. A general and large diminution of electromotive force at the higher temperature. And 3rd. A much smaller increase of that force on the addition of the first portion of the substance. The differences would probably have been less conspicuous if the solutions in each case had been much weaker. These results support the conclusion that potassium bromide behaves to a certain extent like a different substance at each different temperature.

Curves of Isomeric Electrolytes (Fig. 5).

I have already shown (see *Phil. Mag.*, October, 1889, p. 289, "On the Molecular Constitution of Isomeric Solutions") that aqueous isomeric electrolytes yield different amounts of voltaic energy with a zinc-platinum couple. In the present case I employed the same pair of mixed aqueous solutions as were used in that research, viz., an unstable one, "A," having a composition represented by the formula $Na_2SO_4 + 2HNO_3$, and yielding an average voltaic energy = 77,446 ; and its stable isomer, "B," represented by $2NaNO_3 + H_2SO_4$, and yielding 32,722. The degrees of strength of the series of solutions employed were those which were the most easily worked, and were from ·01 to ·1 grain of the mixture in 155 grains of water. The constituent solutions of "A," previous to being mixed, contained ·01 grain of substance per cubic centimetre ; if they were stronger than this there was risk of the liquid undergoing a chemical change during the mixing.

These curves show, much more completely than any single pair of measurements of voltaic energy could do, the considerable differences between the molecular and chemical constitutions of the two liquids. Nearly throughout its entire range the curve of "A" shows a greater degree of electromotive force than that of "B." As the unstable liquid "A" is readily changed into the stable one "B" by merely heating it to nearly 100° C. in a stoppered glass flask during 15 minutes, and then would give the curve of "B," it is evident that the method of examining aqueous solutions by means of curves of electromotive force is applicable for detecting and measuring chemical and molecular changes in them.

B. Curves by Varying the Strength of the Solution at One Metal only.

The kind of apparatus employed is shown by the annexed sketch (Fig. 6), and is formed of glass. A weak solution, containing one grain of the substance in 465 grains of water, was put, together with the negative metal, platinum, into the short leg of the tube, and successive portions of solution, of regularly decreasing strength, in 465 grains of water, were put, together with the positive metal, unamalgamated zinc, into the long leg, and the electromotive force with each strength of solution was measured. The positions of the metals were then reversed, and the measurements repeated. The glass tap was closed during the process of changing each strength of liquid. In consequence of the much greater conduction resistance in the constricted portions of the solutions, the degrees of electromotive force were all much smaller than if the two metals had been near each other in the same leg. Fig. 7 shows the results obtained with solutions of KBr.

The curves show that the variation of strength of the liquid had a large effect upon the electromotive force at the surface of the zinc, but scarcely any such effect at that of the platinum ; and we may conclude that when such variation of strength occurs at both metals simultaneously, the effect upon the electromotive force, and consequently also upon the form of the curves, is nearly wholly due to changes of chemical action at the surface of the zinc, and but little to such changes at the platinum.

C. Curves by Varying the Temperature of the Solution at Both Metals.

The solution contained ·01 grain of HCl in 155 grains of water, and the electromotive force was measured every five centigrade degrees from 10°C. to 100°C.

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The curve in Fig. 8 shows:—1st. That the electromotive force varies with the temperature. And 2nd. That a regular variation of temperature of the solution is attended by an irregular change of electromotive force. It is probable that the curve obtained by varying the temperature is characteristic of the substance, and would be different with every different substance and degree of strength of its solution.

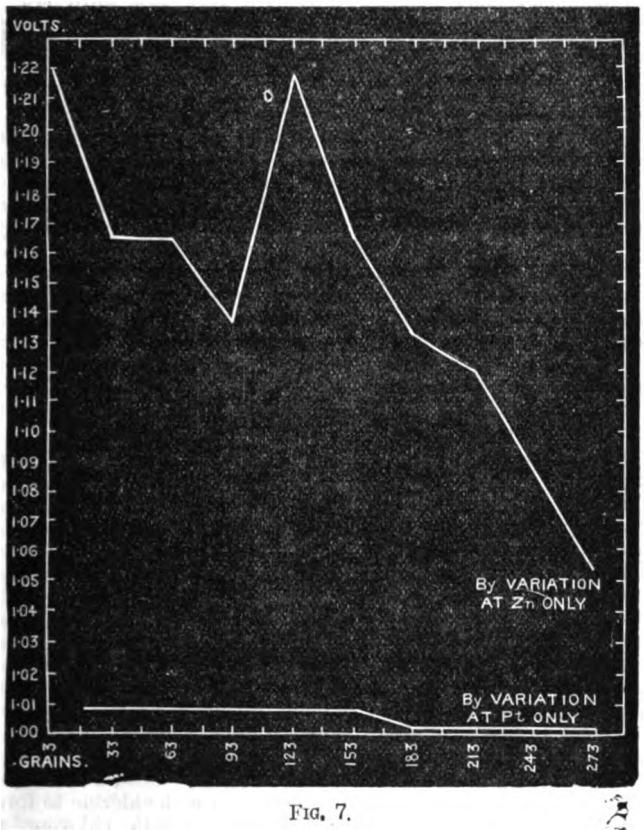

FIG. 7.

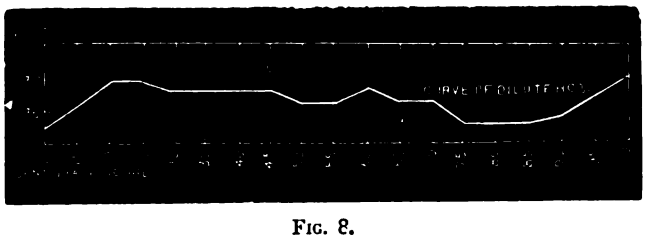

FIG. 8.

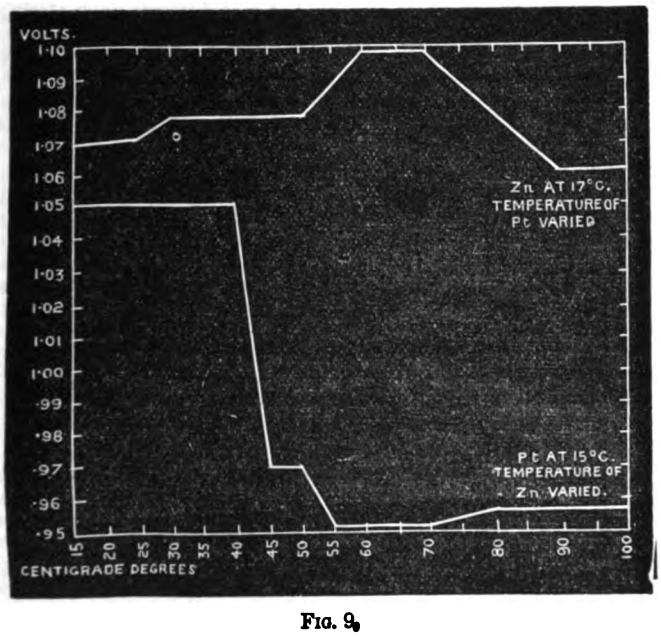

FIG. 9.

D. CURVE BY VARYING THE TEMPERATURE OF THE SOLUTION AT ONE METAL ONLY.

In these measurements the large bent glass tube was employed (*see* Section "B"). The liquid consists of 39 grains of potassium chloride dissolved in 465 grains of previously-boiled distilled water. In one series of measurements the zinc was immersed in the heated portion of liquid, and the platinum in the cold portion; and in the other series the reverse. Fig. 9 shows the curves obtained.

The two curves are very different. The greatest variation of electromotive force was at the zinc, and was = ·103 volt, whilst that at the surface of the platinum was only = ·04 volt. The results show that the change of electromotive force which occurred on gradually heating an electrolyte and the two metals in it is a concrete effect of two influences, one of which is situated at the surface of the positive metal and the other at that of the negative one. Each of these two influences itself would also probably be a compound effect of the separate actions of heat upon the metal and upon the liquid. These general effects of variation of temperature described in Sections "C" and "D" are very similar to those of change of strength of liquid given in Sections "A" and "B."

E. GENERAL AND THEORETICAL CONSIDERATIONS.

The evidence obtained by this research shows:—1st. That every different electrolytic substance when in aqueous solution gives, by varying the degree of strength of its solution (or by varying its temperature), a different curve of electromotive force. 2nd. That this curve is characteristic of the substance. 3rd. That under these conditions, substances which constitute a recognised chemical group yield a series of curves which usually exhibit a gradation of likeness of form. 4th. That the degrees of electromotive force of such a group usually vary in magitude inversely as the amounts of the atomic and molecular weights of the substances. 5th. That a much greater increase of electromotive force is usually caused by the first amount of substance added to the water than by the subsequent amounts. 6th. That the chemical union of two substances to form a soluble salt is attended by a definite decrease of electromotive force and a definite change of form of curve. 7th. That the substitution of one halogen, acid, or metallic base for another in the composition of a soluble electrolytic salt, is accompanied by a definite amount of change of that force and of the form of its curve; and it will be possible to trace, by means of these changes, the presence of each halogen, acid, and metal in the various solutions of its salts. 8th. That isomeric solutions of electrolytic substances give different curves under the same conditions, and may thus be distinguished from each other. 9th, That molecular and chemical changes and their rates, in electrolytes, may be examined and measured by this method. And 10th. That if the solutions of the substances are too weak, the characteristic forms and differences of the curves are not fully developed, and if they are too strong the measurements of electromotive force are more difficult to make. As the measurements were made at the null point when no current was passing, the curves represent the electromotive forces and molecular motions which exist under that condition; when the current passes, the molecular movements are greatly altered.

The changes of electromotive force and forms of curve obtained, —1st, by the same variations of strength of the same solution at two different temperatures; 2nd, by varying the temperature of a solution without changing its strength; and 3rd, by varying its temperature at the positive metal only, or at the negative one only, support the general view that each substance becomes more or less a different substance at each different temperature, and that the degrees of property of each substance at different temperatures are practically infinite in number.

The results in general support the kinetic theory that the most fundamental attribute of matter is motion, that a mass of matter is a mass of motion, that each substance consists essentially of a collection of molecular motions, and that the chief properties of bodies are consequences of such motions. Changes of volta-electromotive force are now generally recognised as being due to those motions, and as being disturbances of the universal ether which pervades all bodies and all space. Each degree of such force may also be regarded as a concrete result of an extensive series of molecular vibrations of extremely varied degrees of amplitude; this series being characteristic of the particular material combination producing it, analogous to the collection of vibrations producing a beam of light of a particular burning substance. The curves represent in addition the changes in amount of these motions; and by observing these changes in a single substance under a sufficient variety of conditions, a more or less complete graphic delineation of them as representing that particular substance might be obtained. When we are able to fully interpret the language or meaning of these curves, we shall learn a very great deal respecting the internal motions and changes of substances, and the conditions of conversion of potential into kinetic energy.

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As each curve is a geometrical and quantitative representation of a series of such changes, a complete collection of such curves, yielded by all kinds of aqueous solutions, would constitute an extensive system of representations of the molecular motions of substances somewhat like that of the luminous spectra of bodies; and the magnitudes and harmonic relations of the degrees of electromotive force represented by the curves will form a very large basis of study for mathematicians, such as the spectra of bodies now afford. The entire subject appears to be nearly as large as that of spectrum analysis, and is not altogether unlike it.

The whole system of curves may be viewed as being in some respects analogous to the absorption-spectra of liquids, and in a less degree to the spectra of gases. The relations between the different curves are probably more complex than those between the spectra of liquids, because the electrodes take part in the action: and still more complex than those between the spectra of gases, because of the influences of the solvent and of the electrodes, and because each dissolved substance is in the liquid state and under the influence of cohesion.

As the magnitudes and forms of the curves are manifestly related to the atomic and molecular weights of the dissolved sustances, they are doubtless also related to the periodic series, and in this direction a study of them by mathematicians will lead to the acquisition of new knowledge. And as they reveal the kinetic changes which isomeric and other substances undergo when they pass from one state of chemical equlibrium to another in cases of chemical union, substitution, and decomposition, &c., they are evidently related very intimately to Newton's third law of motion.

With regard to the latter suggestion, in several researches (see "Relative Amounts of Voltaic Energy of Electrolytes," Roy. Soc. *Proc.* November, 1888, XLV. p. 266; "On Loss of Voltaic Energy of Electrolytes by Chemical Union," *Proc.* Birm. Philos. Soc., December, 1888, VI. p. 225; "Relative Amounts of Available Voltaic Energy of Aqueous Solutions," *ibid.* VII. part 1; "Examples of Solution Compounds," *ibid.* and *Chemical News*, April, 1890), I have largely shown, by means of the "voltaic balance" method, that chemical union in definite proportions by weight of substances *whilst in aqueous solution together* is apparently universal; that elements unite with elements, with all kinds of acids, and with all classes of acid, neutral, and basic salts; that acids unite with acids, each with every other one, and each acid with every salt; and salts with each other in almost endless variety; and apparently that all kinds of dissolved chemical compounds, with but few, if any, exceptions, unite together more or less distinctly, in those definite proportions indiscriminately and without limit of kind, provided no separation of substance by precipitation or otherwise occurs. Also, by repeatedly doubling the molecular weight of a "solution compound" by successive additions to it of other dissolved substances of equal chemical value, each addition producing a new state of chemical equilibrium, in which chemical action and reaction are equal, I have by the same method shown that chemical union of substances whilst in aqueous solution together extends to large aggregates of molecules of the most varied kind and of considerable degrees of complexity (*Proc.*, Birm. Phil. Soc., VI., p. 225). This universality of chemical union of substances whilst in solution together indicated the existence of an equally general cause of such union, and that cause must be a molecular one.

"The theory most consistent with these facts is a kinetic one, viz, that metals and electrolytes are throughout their masses in a state of molecular movement. That the molecules of these substances, being frictionless bodies in a frictionless medium, and their motion not being dissipated by conduction or otherwise, continue in motion until some cause arises to prevent them. That every different metal and electrolyte has a different class of motions, and that the molecular motion of each substance varies at a different rate by rise of temperature." This theory has been employed by me to explain certain thermo-electric phenomena in electrolytes (*see* Roy. Soc. *Proc*, 1883, XXXVI., pp. 54-55). "In accordance with this theory chemical action is an effect of molecular motion, and is one of the modes by which that motion is converted into electric current." "These statements are also consistent with the view that the elementary substances lose a portion of their molecular activity when they unite to form acids or salts, and that electrolytes have usually a less degree of molecular motion than the elements of which they are composed" (*ibid.*).

A kinetic theory must agree with mechanical laws; we cannot create motion or energy, all motion arises from pre-existing motion, every efficient cause of material change is a kinetic one; the immediate source of all chemical change is the latent molecular motion of the combining or mutually acting substances. As neither mere difference of substance, nor union in definite proportions by weight, is in itself an active influence, neither can it be the immediate kinetic cause of chemical change; but as both these circumstances invariably attend chemical union, and no such union occurs without them, we may conclude that they are necessary conditions of the union.

By adopting the above theory, "that electrolytes are throughout their masses in a state of molecular movement; that the molecules of these substances, being frictionless bodies in a frictionless medium, and their motion not being dissipated by conduction or otherwise, they continue incessantly in movement until some cause arises to prevent them," and associating it with Newton's third law of motion, viz, that "the actions of bodies upon one another are always equal and in opposite directions," we are driven to the inference that what we term "chemical affinity," or the immediate active cause of chemical union, is latent or potential molecular motion and the mutual impact and momentum of the molecules of the uniting substances. When two dissolved substances are brought by admixture of their solutions into mutual contact, a portion of the molecular motion of the one substance is neutralised by an equal amount of opposite motion of the other, and the two portions are converted into free heat, electric current, or other form of energy, and the molecules thus brought into near proximity retain their new positions and distances: this agrees with the usual evolution of heat, loss of voltaic energy, depression of electromotive force, and frequent increase of density, which occur during chemical union. According to this view, every dissolved chemical compound is an instance of balanced molecular motion, and it is the neutralised portions of motion which escape as heat and electric current. How far there is any originality in these ideas I leave to other persons to decide.

Many of the facts evolved by the several researches I have referred to point towards the conclusion that measurements of volta-electromotive force and voltaic energy are essentially measurements of "chemical affinity" between the dissolved substance and the positive metal. An analogous idea has already been suggested by other investigators. E. F. Herroun, adopting a view of Helmholtz's, has inferred that "the electromotive force of a voltaic cell is a measure of the actual transformation of free energy," and concluded that it "furnishes a more accurate measurement of the free energy, and therefore of true chemical affinity, than data derived from calorimetric observations" (*Phil. Mag.*, 1888, XXVII., pp. 230, 233). The amounts of voltaic energy lost by two substances during their act of chemical union clearly indicate to a large extent the quantities of opposite molecular motion neutralised by their union. For instance, a much larger amount of such motion is neutralised by the union of sodium with chlorine to form sodic chloride than by that of hydrogen with chlorine to form hydrochloric acid: and, no doubt, by investigating the losses of electromotive force and voltaic energy attending the chemical union of substances in aqueous solution, we may learn a very great deal respecting the quantitative relations of "chemical affinity" between metals and electrolytes; but a great obstacle to making accurate measurements of such "affinity" by this method is the unmeasured portion of energy lost by "local action." It may be further remarked that, disregarding "local action," this chemical union and neutralisation of opposite molecular motions only occurs whilst the circuit is closed; and that at the instant of closing the circuit, potential energy is converted into kinetic energy, and a multitude of electro-magnetic waves of very varied lengths are generated and radiated into space: the conversion of energy, therefore, in this kind of case depends upon closing of the circuit.

The results obtained by varying the strength or the temperature of the liquid at each metal separately support the conclusion that, in an ordinary voltaic cell, nearly the whole of the energy is due to action at the zinc, and but little to that at the platinum; and that the latter acts nearly wholly by obviating the greater counter electromotive force which would occur by using a more corrodible metal, and by diminishing the resistance which a less conducting substance would offer. The more absence of an obstacle to a change cannot be an active cause of that change; and any substance which takes an essential part in any physical or chemical action, and (like the platinum plate) remains exactly the same in every respect after the action as it was immediately previous to it, cannot have been a real cause of that action, or of any loss or gain of energy attending it. The presence of the negative metal is only a static permitting condition; it enables, without any expenditure of energy on its own part, the opposite potential molecular motions of the positive metal and the liquid to neutralise each other and to be converted into voltaic current.

The method described in this Paper is not merely a technical one of detecting substances, nor is it specially fitted for such a purpose; but it is an extensive new department of chemical and molecular research, and a general system of representation by means of geometrical curves, not only of individual substances, but of some of the fundamental changes of molecular motion of substances which are inseparably related to their chief chemical properties; and it will in this way supply mathematicians with a new and extensive series of facts, representing, in terms of electromotive force, the degrees of volta-chemical action of metals and electrolytes upon each other. One of the chief uses of it as a method of research will be to examine the molecular structure and chemical

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composition of dissolved substances, to detect differences and changes in them caused by heat, light, chemical union, substitution, or decomposition, &c.; and to detect and measure molecular and chemical differences in isomeric liquids. It may be used to detect and measure the changes gradually produced by light and heat in chlorine water and bromine water, the influence of light upon nitric acid, the degrees of retarding effect of coloured glass screens, &c., upon various chemical changes caused by light, the gradual oxidation of a solution of sulphurous anhydride by exposure to air, the spontaneous decomposition of aqua regia, the rate of decomposition of a solution of potassic iodide by chlorine water, the speed of displacement of one acid by another, &c. The examples given and researches suggested are sufficient to indicate the very great extent of the subject.

THE BRITISH ASSOCIATION AT LEEDS.

The second meeting of the British Association at Leeds opened on Wednesday morning by the assembling of the General Committee, under the presidency of Professor Flower, F.R.S., the retiring president, to receive the report of the council for the year 1889-90, and to elect the sectional officers.

After the reception of the report and the adoption of various recommendations, the committee proceeded to elect the sectional officers for the ensuing meetings. The following gentlemen were elected in Sections A and G.:—

A.—Mathematical and Physical Science.—President, J. W. L. Glaisher; vice-presidents, Professor O. J. Lodge, Professor Rucker, Lord Rayleigh, Professor H. H. Rowland, Sir Wm. Thomson, Professor E. Mascart; secretaries, R. T. Glazebrook, Professor A. Lodge, W. N. Shaw, Professor W. Stroud.

G.—Mechanical Science.—President, Captain A. Noble; vice-presidents, Professor L. F. Vernon Harcourt, G. F. Deacon, Professor V. Dwelshauvers-Dery, A. Greenwood, Sir James Kitson, B. Walker; secretaries, E. K. Clark, C. W. Cooke, W. Bayley Marshall, E. Rigg (recorder).

The evening meeting took place at 8 o'clock in the Coliseum, Cookridge-street, when Sir F. Abel delivered the following address:—

Sir Frederick Abel's Presidential Address.

After referring in touching terms to the gaps created in the ranks of those who were prominent at the meeting of the British Association at Leeds 32 years ago, Sir FREDERICK ABEL said:—To not a few of those who have flocked to Leeds to attend the annual gathering of this Association, our present meeting place is doubtless known chiefly by its proud position as one of the most thriving manufacturing towns of the United Kingdom; of ancient renown, especially in connection with one of the chief industries identified with Great Britain in years past. But this good town of Leeds, whose cloth market was described by Daniel Defoe, 160 odd years ago, as "a prodigy of its kind, and not to be equalled in the world," and whose present position in connection with divers of our great industries would have equally excited the enthusiasm of that graphic writer, is famous for other things than its prominent association with manufactures and commerce. Not many of our great industrial centres can boast of so goodly an array upon the scroll of their past history of names of men eminent in the sciences, the arts and manufactures, in divinity and letters, and in heroic achievements, such as are identified with Leeds and its immediate vicinity—Thomas, Lord Fairfax, one of the most prominent heroes of the Commonwealth; Smeaton, an intellectual giant among engineers; William Hirst and John Marshall, illustrious examples of the men who by their genius, energy, and perseverance placed Great Britain upon the pinnacle of industrial and commercial greatness which she so long occupied unassailed; Richard Bentley, the eminent classic and divine; John Nicholson, the Airedale poet; John Fowler and Peter Fairbairn, worthy followers in the footsteps of Smeaton; Isaac Milner, weaver and mathematician, afterwards Senior Wrangler, Smith's Prizeman, Jacksonian Professor, President of Queens' College, Vice-Chancellor of Cambridge University, Dean of Carlisle, and a most illustrious Fellow of the Royal Society; Thoresby, antiquary and topographer; Benjamin Wilson, painter and industrious contributor to the development of electrical science; William Hey, the eminent surgeon, and friend and counsellor of Priestley; Sadler, political economist and philanthropist; the brothers Sheepshanks—Richard, the astronomer, and John, the accomplished patron of the arts and munificent contributor to our national art treasures; Edward Baines, whose conspicuous talents and energy developed a small provincial journal into one of the most powerful public organs of the country; his talented sons, of whom not the least conspicuous and highly respected was the late Sir Edward Baines. I might swell this voluminous list by reference to illustrious members of such families as that of Denison, of Beckett, of Lowther, but the men I have referred to fitly illustrate the remarkable array of worthies whose careers have shed lustre upon the town in or near which they were born. Yet that illustration would be altogether incomplete if I failed to speak of one whose career and works alone would suffice to place Leeds in the foremost rank of those English towns who can claim as their own men whose course of life and whose achievements have secured their pre-eminence among our illustrious countrymen. Needless to say I refer to Joseph Priestley, born within six miles of Leeds, whose name holds rank among the foremost of successful workers in science; who, by brilliant powers of experimental investigation, rapidly achieved a series of discoveries which helped largely to dispel the shroud of mystery surrounding the art of alchemy and to lay the foundation of true chemical science. His great quickness of perception and power of experiment led him to the achievement of many novel and important results; but one cannot help contrasting his somewhat random search after new discoveries with the close logical reasoning and philosophic spirit which guided and pervaded the remarkable researches of him whose departure from amongst us since the last gathering of this Association is so universally deplored—of the great discoverer of the universal law of the conversion of energy, James Prescott Joule.

Among the branches of science in the practical applications of which the greatest strides have been made since the Association met at Leeds in 1858 is electricity. That year witnessed the accomplishment of the first great step towards the establishment of electrical communication between Europe and America, by the laying of a telegraph cable connecting Newfoundland with Valencia Island. Through this cable a message of 31 words was shortly afterwards transmitted in 35 minutes—an achievement which, though exciting great enthusiasm at the time, scarcely afforded promise of the succession of triumphs of ocean telegraphy which have since surpassed the wildest dreams of the pioneers in the realms of applied electricity. The development of the electric telegraph constitutes a never-failing subject of the liveliest interest. The experiments made more than a century and a-half ago by Stephen Gray, by Watson, and by Franklin, of transmitting frictional electricity through considerable lengths of wire—although they were followed by many other interesting and philosophical applications of frictional electricity to the transmission of signals—were not productive of really practical results. The work of Galvani and of Volta was more fruitful of an approach to practical telegraphy in the hands of Sömmering and of Coxe, while the researches of Oersted, of Ampère, of Sturgeon, and of Ohm, and especially the discoveries of volta-electric induction and magneto-electricity by Faraday, paved the way for the development of the electric telegraph as a practical reality by Cooke and Wheatstone in 1837. How remarkable the strides have been in the resources and powers of the telegraphist since that time is demonstrated by a few such facts as these: The first needle instrument of Cooke and Wheatstone transmitted messages at the rate of four words per minute, requiring five wires for that purpose; six messages are now conveyed by one single wire at ten times that speed, and news is despatched at the rate of 600 words per minute. Duplex working, which more than doubled the transmitting power of a submarine cable, was soon eclipsed by the application of Edison's quadruplex working, which has in its turn been surpassed by the multiplex system, whereby six messages may be sent independently, in either direction, on one wire. When last the British Association met in Leeds, submarine telegraphy had but just started into existence; 30 years later the accomplished President of the Mechanical Section informed us, at our meeting at Bath, that 110,000 miles of cable had been laid by British ships, and that a fleet of nearly 40 ships was occupied in various oceans in maintaining existing cables and laying new ones.

The important practical achievements by which most formidable difficulties have been surmounted step by step, in the successive attainment of the marvellous results of our day, have exerted an influence upon the advancement not merely of electrical science, but also of science generally and of its applications, fully equal to that which they have exercised upon the development of commerce and of the intercourse between the nations of the earth. Thus, the laying of the earliest submarine cables, between 1851 and 1855, led Sir W. Thomson, in conference with Sir George Stokes, to work out the theory of signalling in such cables, by utilizing the mathematical results arrived at by Fourier in his investigation of the propagation of heat-waves. The failure of the first Atlantic cable led to the survey of the bottom of the Atlantic, which was the forerunner of deep-sea explorations, culminating in the work of the "Challenger" expedition, and opening up new treasures of knowledge scarcely dreamt of when last the British Association met at Leeds. To the difficulties connected with the early attempts at submarine telegraphy, and the determination with which Thomson drove home the lessons learnt, we owe the systematic investigations into the causes of the variations in resistance of copper conductors, and the consequent improvements in the metallurgy of copper, which led to the realization of the high standard of purity of metal essential for the efficient working of telegraphic systems, and also to the extensive utilization of electricity in the production of pure copper. The rare combination of originality in powers of research and perspicuity in mathematical reasoning, with inventive and constructive genius, for which Thomson has for so long been pre-eminent, has placed at the disposal of the investigator of electric science and of the practical electrician instruments of measurement and record which have been of incalculable value, and which owe their origin to the theoretical conclusions arrived at by him in his researches into the conditions to be fulfilled for the attainment of practical success in the construction and employment of submarine cables. The mirror galvanometer, the quadrant electrometer, the syphon-recorder, and the divided-ring electrometer are illustrations of the valuable outcome of Thomson's labours; the combination of the last-named instrument with sliding resistance coils has rendered possible the accurate sub-division of a potential difference into 10,000 equal parts. The general use of condensers in connection with cable signalling, due to Varley's application of them for signalling through submerged cables with induced short waves, was instrumental in establishing

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the fact that all electrostatic phenomena are simply the result of starting an electric current of known short duration round a closed circuit. The practical application of the Wheatstone bridge led to numerous important mathematical investigations, and induced Clerk Maxwell to devise a new mode of applying determinants to the solution of the complicated electrical problems connected with networks of conductors. The necessity for the universal recognition of an electrical unit of resistance led to the establishment, in 1860, of the Electrical Standards Committee of the British Association, whose long succession of important annual reports was instrumental in most important developments of theoretical electricity, and, indeed, served to open up the whole science of electrical measurement. Mattheissen's important investigations of the electrical behaviour of metals and their alloys and the preparation and properties of pure iron were the outcome of the commercial demand for a practically useful standard of electrical resistance, while Latimer Clark's practical standard of electromotive force, the mercurous sulphate cell, became invaluable to the worker in pure electrical research. The unit of resistance established by the British Association Committee received, in 1866, most important scientific application at the hands of Joule, who, by measuring the rate of development of heat in a wire of known resistance by the passage of a known current, obtained a new value of the mechanical equivalent of heat. This value differed by about 1·3 per cent. from the most accurate results arrived at by his experiments on mechanical friction, a difference which eventually proved to be exactly the error in the British Association unit of resistance; so that the true value of the unit of resistance, or ohm, was determined by Joule 15 years before this result was achieved by electricians. Clerk Maxwell's remarkable electro-magnetic theory of light was put to the test, through the aid of the British Association unit of resistance, by Thomson, in determining the ratio of electro-magnetic unit to the electro-static unit of quantity. Many other most interesting illustrations might be given of the invaluable aid afforded to purely scientific research by the practical results of the development of electrical science, and of the constant co-operation between the science student and the practical worker. No one could more fitly than the late Sir William Siemens have maintained, as he did in his admirable address at our meeting in Southampton, in 1882, that we owe most of the rapid progress of recent times to the man of science who partly devotes his energies to the solution of practical problems, and to the practitioner who finds relaxation in the prosecution of purely scientific inquiries. Most assuredly, both these classes of the world's benefactors may with equal right lay claim to rank the name of Siemens among those whom they count most illustrious.

After glancing at the early history of electric lighting and of the telephone, Sir Frederick continued:—Nine lighting companies either are now, or will very shortly be, actually at work, supplying, from central stations, districts of London comprising almost the entire western and north-western portions of the metropolis. As regards other parts of England, there are already 27 lighting stations actually at work in different towns, besides others in course of establishment, and many more projected. The town of Leeds has not failed to give serious attention to the subject of utilising the electric light, and although no general scheme has yet been adopted, the electricians who now visit this town will rejoice to see many of its public buildings provided with efficient electric illumination. While the prediction made by Siemens eight years ago, that electric lighting must take its place with us as a public illuminant, has thus been already, in a measure, fulfilled, important progress is being continuously made in developing and perfecting the arrangements for the generation of the supply, its efficient distribution from centres, and its delivery to the consumer in a form in which it can be safely and conveniently dealt with and applied at an outlay which even now does not preclude a considerable section of the public from enjoying the decided advantages presented by electric lighting over illumination by coal gas. Yet our recent progress in this direction, encouraging though it has been, is insignificant as compared with the strides made in the application of electric lighting in the United States, as may be gauged by the fact that, while in America the number of arc lamps in use in April of this year was 235,000, and of glow lamps about 3,000,000, there are at present about one-tenth the number of the latter, and one-hundredth the number of arc lamps, in operation in England. In some important directions we may, however, lay claim to rank foremost in the application of the electric light; thus, our large passenger ships and our war ships are provided with efficient electrical illumination; to the active operations of our Navy the electric light has become an indispensable adjunct; and our system of coast defence, by artillery and submarine mines, is equally dependent for its thorough efficiency upon the applications of electricity in connection with range-finding, with the arrangement and explosion of mines, and with the important auxiliary in attack and defence the electric light, which, while so arranged at the operating stations as to be protected against destruction by artillery fire and difficult of detection by the enemy, is available at any moment for affording invaluable information and important assistance and protection. Other important applications of the electric light, such as its use as a lighthouse illuminant, for the lighting of main roads in coal mines, and even for signalling purposes in mid-air, through the agency of captive balloons, are continually affording fresh demonstrations of the value of this particular branch of applied electric science.

The achievements of the telephone were referred to by Siemens in glowing terms eight years ago; but the results then attained were but indications of the direction in which telephonic intercommunication was destined speedily to become one of the most indispensable of present applications of electricity to the purposes of daily life. Preece, in speaking at Bath two years ago of the advances made in applied electricity, showed that the impediments to telephonic communication between great distances had been entirely overcome; and now, although considerably behind America and France in the use of the telephone, we are rapidly placing ourselves upon speaking terms with our friends throughout the United Kingdom. The operations of the National Telephone Company well illustrate our progress in telephonic intercommunication. That company has now 22,743 exchange lines, besides nearly 5,000 private lines, its exchanges number 272, and its call offices 526. The number of instruments under rental in England has now reached 99,000; but, important as this figure is compared to our use of the telephone a very few years ago, it sinks into insignificance by the side of the number of instruments under rental in America, which at the beginning of the present year had reached 222,430, being an increase of 16,675 over the number in 1889. Only thirteen years have elapsed since the telephone was first exhibited as a practically workable apparatus to members of the British Association at the Plymouth meeting, and the number of instruments now at work throughout the world may be estimated as considerably exceeding a million.

The successful transmission of the electric current is not alone illustrated by the efficiency of the arrangements already developed for the supply of the electric light from central stations. Siemens dwelt upon this subject at Southampton with the ardent interest of one who had made its development one of the objects of his energetic labours in later years, and also with a prophet's prognostications of its future importance. He pointed out that no further loss of power was involved in the transformation of electrical into mechanical energy than is due to friction, and to the heating of the conducting wires by the resistance they oppose, and showed that this loss, calculated upon data arrived at by Dr. John Hopkinson and by himself, amounted at the outside to 38 per cent. of the total energy. Subsequent careful researches by the brothers Hopkinson have demonstrated that as much as 87 per cent. of the total energy transmitted is realisable at a distance, provided there be no loss in the connecting leads used. The Paris Electrical Exhibition of 1881 already afforded interesting illustrations of the performance of a variety of work by power electrically transmitted, including a short line of railway constructed by the firm of Siemens, which was a further development of the successful result already attained in Berlin by Werner Siemens in the same direction, and was, in its turn, surpassed by the considerably longer line worked by Messrs. Siemens at the Vienna Exhibition two years later. Various short lines which have since then been established by the firm of Seimens are well known, and one of the latest public acts in the valuable life of Siemens was to assist at the opening of the electric tramway at Portrush, where the idea, so firmly rooted in his mind from the date of his visit to the falls of Niagara in 1876, of utilising water-power for electrical transmission—a result first achieved on a small scale by Lord Armstrong—was more practically realised than had yet been the case. Since that time Ireland has witnessed a further application of electricity to traction purposes, and of water-power to the provision of the required energy, in the working of the Bessbrook and Newry tramway, while London at length possesses an electric railway, three miles in length, to be very shortly opened, which will connect the city with one of the southern suburbs through a tram subway, and, although including many sharp curves and steep gradients, will be capable of conveying 100 passengers at a time, at speeds varying from 13 to 24 miles per hour. During the past year a regular service of tramcars has been successfully worked, through the agency of secondary batteries, upon part of one of the large tramways of North London, with results which bid fair to lead to an extensive development of this system of working.

The application of electricity to traction purposes has, however, received far more important development in the United States; at the commencement of this year there were in operation in different States 200 electrical tramroads, having a collective length of 1,641 miles, with 2,346 motor-cars travelling thereon. The idea cherished by Siemens of utilising the power of Niagara appears about to be realised, at any rate in part, as a large tract of land has been recently acquired by a powerful American association, about a mile distant from the Falls, with a view to the erection of mills for utilising the power, which it is also proposed to transmit to distant towns; and an International Commission, with Sir William Thomson at its head, and with Mascart, Turrettini, Coleman Sellers, and Unwin as members, will carefully consider the problems involved in the execution of this grand scheme. The application of electric traction to water traffic, first successfully demonstrated in 1883, is receiving gradual development, as illustrated by the considerable number of pleasure-boats which may now be seen on the Upper Thames during the boating season. Electrically transmitted energy was first applied in Germany to haulage work in mines by the firm of Siemens some years ago, and great progress has since been achieved herein on the Continent and in America. It is very interesting to note, on the present occasion, that the first successful practical application of electricity in this country to pumping and underground haulage work was made in 1887, in this neighbourhood, at the St. John's Colliery at Normanton, where an extensive installation is furnishing very satisfactory results in point of economy and efficiency. The gigantic installations existing for the same purposes in Nevada and California afford remarkable illustrations of the work to be accomplished in the future by electrically transmitted energy.

Among the many subjects of importance studied by Joule with the originality and thoroughness characteristic of his work, was the application of voltaic electricity to the welding and fusion of metals. Thirty-four years ago he published a most suggestive paper on the subject, in which, after dealing with the difficulties attending the operation of welding, and of the interference of films of oxide, formed upon the highly heated iron surfaces, with the production of perfect welds either under the hammer or by the methods of pressure (of which he then predicted the application to large masses of forged iron), he refers to the possibility of applying the calorific agency of the electric current to the welding of metals, and describes an operation witnessed by him in the laboratory of his fellow-labourer, Thomson, of fusing together a bundle of iron wires by transmitting through them, when imbedded in charcoal, a powerful voltaic

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current. Joule afterwards succeeded in fusing together a number of iron wires with a current of a Daniell battery, and of welding together wires of brass and steel, platinum and iron, &c. In discussing the question of the amount of zinc consumed in a battery for raising a given amount of iron to the temperature of fusion, he points out that the same object would probably be more economically attained by the use of a magneto-electric machine, which would allow the heat to be provided by the expenditure of mechanical force developed in the first instance by the expenditure of heat; and he indicates the possibility of arranging machinery to produce electric currents which shall evolve one-tenth of the total heat due to the combustion of the coal used, so that 5,000 grains of coal applied through that agency would suffice for the fusion of one pound of iron. The successful practical realisation of Joule's predictions in regard to the application of electric currents, thus developed, to the welding of iron and steel, and to analogous operations, through the agency of the efficient machines devised by Professor Elihu Thomson, was demonstrated to the members of the Association by Professor Ayrton at Bath two years ago, and was shown upon a larger scale to visitors at the Paris Exhibition last year, and recently to highly interested audiences in London by our late president, Sir Frederick Bramwell. The latter demonstrated that the production of iron welds by means of the Thomson machines was accomplished nearly twice as rapidly as by expert craftsmen; the perfection of the welds being proved by the fact that the strength of bars broken by tensile strains at the welds themselves was about 92 per cent. of the strength of the solid metal. Another very simple system of electric welding, especially applicable to thin iron and steel sheets, hoops, &c., has been contemporaneously elaborated in Russia by Dr. Benardos, and is already being extensively used. The required heat at the surfaces to be welded is developed by connecting the metal with the negative pole of the dynamo machine, or of a battery of accumulators, the circuit being completed by applying a carbon electrode to the parts to be heated. This mode of operation appears to have been practised upon a small scale, some years ago, by Sir William Siemens, to whom we also owe the first attempt to practically apply electric energy to the smelting of metals. In his address in 1882 he pointed out that, although electric energy could, obviously, not compete economically with the direct combustion of fuel for the production of ordinary degrees of heat, the electric furnace would probably receive advantageous application for the attainment of temperatures exceeding the limits (about 1,800°C.) beyond which combustion was known to proceed very sluggishly. This prediction appears to have been already realised through the important labours of Messrs. Cowles. After very promising preliminary experiments, they succeeded, in 1885, in maturing a method of operation for the production of aluminium-bronze, ferro-aluminium, and silicium-bronze, with results so satisfactory as to lead to the erection of extensive works at Lockport, New York, where three dynamo machines, each supplying a current of about 3,000 amperes, are worked by water-power, through the agency of turbines, each of 500 horse-power, 18 electric furnaces being now in operation for the production of aluminium alloys. These achievements have led to the establishment of similar works in North Staffordshire, where a gigantic dynamo machine has been erected, furnishing a current of 5,000 amperes, with an electromotive force of 50 to 60 volts.

Turning next to the question of metallurgy, the President said: The careful systematic study of the modifications developed in certain physical properties of iron and steel by gradual changes of temperature between fusion of the metal and the normal temperature has shown those modifications to be governed by a constant law. This important subject, which was so clearly brought before the Association last year in the interesting lecture of Roberts-Austen, has been and is still being pursued by accomplished workers, among whom the most prominent is F. Osmond. The phenomenon of recalescence, or the re-glowing of iron and steel at certain stages during the cooling process, appears to be the result of actual chemical combination between the metal and its contained carbon at the particular temperature attained at the time; while the absorption of heat, or arrest in rise of temperature during its continuous application to the metal, is ascribed to the elimination, within the mass, of carbon as an iron-carbide perfectly stable at low temperatures.

After a short reference to the progress made by sanitary science since the period of the Crimean war, and to the approaching meeting in London of the International Congress on Hygiene and Demography, Sir Frederick Abel dealt with the subject of explosives, passing on then to the provisions for technical education at Leeds:—An examination into the present educational resources of Leeds places beyond any doubt the fact that her present prosperity in commerce and industries is in no small degree ascribable to the paramount importance long since attached here to the liberal provision of facilities for the diffusion of knowledge among the artisan and industrial classes, and especially for the acquisition of a sound acquaintance with the principles of the sciences and their applications to technical purposes, with particular reference to the prominent local industries, by all grades of those who pursue or intend to pursue them. There is probably no town in the kingdom more amply provided with efficient elementary and advanced schools for both sexes, while the special requirements of the artisan are efficiently met by the prosperous School of Science and Technology. The resources of the Yorkshire College provide, in addition, a combination of thorough scientific education with really practical training in the more important local industries; indeed, during the 16 years of its continually-progressive work, this institution has acquired so widespread a reputation, that students come from abroad to reap the advantages afforded by the unrivalled textile and dyeing departments of the Leeds College. The keen competition now existing between these departments and the corresponding branches of the much younger, but most vigorous sister college at Bradford, can only conduce to the further development of both, and to their thorough maintenance up to the requirements of the day. The very important pecuniary aid afforded to these establishments, and to a number of other technical schools in Yorkshire, by one of the most important of the ancient companies of the City of London—the Clothworkers—affords an interesting illustration of the good work in the cause of education performed by those guilds, and, especially of late years, by means of their flourishing institute for the advancement of technical education, which, through its two great instructional establishments in London, and through the operation of its system of examinations throughout the country, extending now even to the Colonies, has afforded very important aid towards eradicating the one great blot upon our national educational organisation. To have been first in the field in practically developing a far-reaching scheme for the advancement of technical education in this country must continue to be a source of pride to the City of London and its ancient Guilds in time to come, when the operation of efficient legislation, supported and extended by patriotic munificence and by the hearty co-operation of associations of earnest and competent workers in the cause, shall have placed the machinery and resources for the technical instruction of the people upon a footing commensurate with our position among nations.

The President then brought his inaugural address to a conclusion by referring to the national importance of Natural History and Natural Science Museums.

ELECTRICAL INDUSTRIES AND THE WORLD'S FAIR.*

BY J. P. BARRETT.

It has been stated by competent authority that had it not been for the exhibition of the speaking telephone at the Centennial Exhibition at Philadelphia, the telephone would have been ten years later in receiving popular recognition and becoming a success. It is well known that the individuals who were nearest the telephone invention looked upon it with distrust, considered it a toy, and an invention of no great practical importance. But Sir William Thomson, who was in 1876, as he is now, the recognised authority in electrical science, seeing the telephone at the Centennial Exhibition, became enthusiastic over it, and endorsed it so warmly that it directed public attention to the invention, and made it an immediate success.

Great as are the interests resulting from the telephone which was first publicly exhibited at the Centennial Exhibition at Philadelphia, the importance of this invention extends beyond the particular interests directly concerned. Fourteen years have passed since then, and in three years more the Columbian Exposition in Chicago will be looked on to exhibit the progress which has been made since that date, and to be commensurate with an industry so progressive as to have absorbed an investment of $500,000,000 in the past ten years. The rivalry in invention has led the United States to outstrip all other nations in the practical application of electricity. Thus it was that the electrical department of the United States Exhibition at the Paris Exposition saved the United States from complete disgrace; and yet the electrical department of the Paris Exposition was the weakest feature of the entire show. Probably the United States in the Columbian Exposition cannot hope to equal Paris in the matter of its general exposition; but in machinery, and in electrical matters particularly, we should do a great deal better.

In the first place, electricity will find numerous applications in the way of actual service in carrying out the plan of the Exposition. By this I refer to the fire alarm protection signalling apparatus, electric lighting, both arc and incandescent, transmission of power, telephoning and telegraphing. The location of the Main Exposition having been settled in favour of the Lake Front, which is practically in the heart of the city of Chicago, and within five squares of the telephone central office, the fire alarm central office, and the Western Union and Postal Telegraph Offices, it will be a matter of no serious difficulty to make such connections with the general city electrical service as will give the Exposition the benefit not only of its own special outfit in each of these directions, but also the advantage of its outside connections. Aside from this application of electricity to the utility and necessities of the Exposition, the features in which we are all particularly interested are those which illustrate the progress that has been made in the science and in the art. The success that has attended recent electrical exhibitions, such as the one in Philadelphia in 1885, and the one in the American Institute Fair in New York, give us some idea of what can be accomplished in this direction with the immensely multiplied facilities at the World's Fair at Chicago, and with the incentive to manufacturers and inventors which comes from having the attention of the whole world directed to their work.

The matter of telegraphy also should receive its due share of attention. The different forms of quadruplex, the use of dynamos

* Abstract of a Paper read before the National Electric Association, Cape May, August, 1890.

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instead of batteries for furnishing the current, and other inventions in which the recent history of the telegraph is prolific, should each and all be suitably presented. Police and fire alarm apparatus of the latest design and the best manufacture, together with all appurtenances, will attract a large share of attention.

Motors for driving machinery, furnishing power for various purposes, running street cars, &c., will, perhaps, be even of more practical benefit than any other application of electricity; while electric lighting apparatus of various kinds will take the lead undoubtedly, as it now does, over all other electrical industries.

It is proposed to connect the two parts of the World's Fair, one situated on the Lake Front and the other at Jackson Park, by means of a railroad built out on the lake. The expediency of adopting electricity for motive power on this railroad is at once obvious. Thus the two features of usefulness and exhibition can readily be combined, and in addition to the direct transmission of power, storage batteries could be employed for traction purposes on this road.

It should be the aim of the people having the exhibition in charge, so to organise and classify the exhibits as to present clearly and forcibly the progress of the art and the present state of its various departments. A chaotic exhibition of the products of the different manufacturers would accomplish something in the way of creating astonishment and mystifying the beholder. It is not too early now to lay plans for the proper presentment of electrical industries for this great Exhibition of 1893. The Exposition should be made just what its name implies, a practical exposition of the progress and advances made in the several branches of the science of electricity, and the exhibits should be so arranged that the various improvements may be seen and appreciated at a glance. Thus will the real object of the Exposition be accomplished and a saving of much valuable time to the visitor be effected. For it is quite probable that fully 50 per cent. of the visitors to the electrical section will go there with the earnest desire to become thoroughly familiar by practical observation and study with all that has been done in some certain industry, either to aid in carrying on a certain line of study or with a view of selecting what they may there conclude is the apparatus best adapted to their needs. In either case, time will be an important and valuable factor, and how to enable each visitor to quickly and understandingly grasp the more important details and points of superiority of any exhibit should be the main object of the respective exhibitors. The usual method followed in the small expositions has been to allot a certain space to each exhibitor and allow him to place therein whatever he may desire to bring to the notice of the visitor. This is a good plan, and one which proves economical in many ways to the exhibitor. Another plan would be to allot space for the various types of apparatus, irrespective of the main display of the exhibitor. That is, to place all telephone apparatus and everything thereto pertaining in close proximity; the same with telegraphic apparatus, arc lighting dynamos, incandescent machines, motors, &c. The carrying out of such a plan will, of course, give two or more separate exhibits to each manufacturer, and thus entail some slight additional expense, both in the matter of suitable furniture, and possibly in the matter of attendance; but all this additional outlay would be more than returned in the excellent results attained, and in the simplifying of the study of any particular type of apparatus, to say nothing of the greater publicity given each exhibit. Of course there would be no objection to an exhibitor's reproducing a complete display of all his wares in the space allotted to him for his headquarters, irrespective of the fact that many articles may also be shown in the respective space to which they belong. In the space allotted to the display of testing instruments the showcases should be placed on a flooring above a foundation made sufficiently solid to prevent oscillation of the needle, or injury to the more delicate parts from vibration or other similar cause. Every article should have a neatly, printed card attached, of size uniform in proportion to the character of the object displayed, bearing the name of the article, the manufacturer's address, and a brief description of its intended use, the same appearing in English, French, German, and Spanish.

At the present time there are about 430 separate companies or individuals whom we can expect to apply for space, many of whom will have but a single article or two to exhibit. But every one of this number will probably defer action until the last possible moment, unless the importance of securing the necessary space and having his exhibit in readiness within the appointed time, is impressed upon him. Some of the manufacturers will have to be coaxed into making exhibits, while others will hesitate on account of the expense entailed. The chief or his secretary must attend to all of this, and must spare no pains to secure not only an exhibit, but the *best exhibit* possible for each manufacturer to make. Great assistance in carrying out a comprehensive and systematic plan for the Exposition may be expected from the United States Census, the report of the Electrical Department of which is looked for with great interest.

A PROPER BASIS FOR DETERMINING ELECTRO-MOTOR RATES.*

BY H. L. LUFKIN.

The equitable adjustment of motor rates, or rather the rates per month, or year, for the supply of current for the operation of electric motors, has long been a matter of considerable annoyance to companies supplying electric power. It is obvious that to invariably charge the motor user an arbitrary rate per horse-power for the motor which he uses, based on its rated capacity, and regardless of the work it is doing, is not satisfactory, for the reason that the manufacturer usually prefers to buy a motor somewhat more powerful than his work really requires and thus avoid the possible damage to his motor from overload, or the strain to which any piece of machinery is subjected when constantly operated above its normal working capacity. Again, the manufacturer may contemplate an increase in his plant in the near future, and, in buying a motor, will provide one of sufficient capacity to operate his prospective increase.

To illustrate graphically the practical operations of motors under load, I have taken a large number of records of motors in actual service, and from these records have laid out ampere curves or daily load diagrams, which illustrate very clearly the fluctuations in the current supplied to motors in actual practice. Other interesting features of these curves are the maximum, minimum, and average readings as related to each other; the current consumed in driving the shafting as related to the average current consumed; and the peculiarity of the records of motors operating elevators.

In one case, in which a 15 horse-power motor works lithograph presses, &c., the maximum reading is 75 amperes, or, approximately, 10 horse-power. The user is given a 10 horse-power rate, which in this case happens to be $60 per month, or a rate of $6 per month per horse-power based on maximum readings. As the average power delivered to this user is but 67 per cent. of the maximum reading, the station actually received at this nominal rate of $6 per horse-power an actual rate of $9 per month per horse-power for the power actually delivered.

The central station supplying this particular motor has adopted the "maximum reading system," and this rate of $6 per month per horse-power is their standard charge for motors showing a reading of 5 horse-power and over up to 15 horse-power. From 15 horse-power up their charge is $5 per month per horse-power. Their monthly bills are also subject to a discount of 5 per cent., I believe, if paid promptly on the first of each month.

The conditions as shown by the diagrams of the current load throughout the day are as follows:—

Average load on motor, 43·57 per cent. of its capacity.
Maximum load on motor, 68·24 per cent. of its capacity.
Average load on motor, 64 per cent. of maximum load.

Reducing these averages to dollars and cents we have the following results:—

A "maximum capacity" rate of $7 per month per horse-power pays the station $13.80 per month per horse-power for the power actually delivered. A "maximum reading" rate of $6 per month per horse-power pays the station $9.37 per month per horse-power for the power actually delivered.

$13.80 per month per horse-power is certainly a tempting price for power, but it is open to some serious objections. In the first place, at this price the electric motor, even with its much higher efficiency, cannot compete with the gas engine. A good gas engine uses about 20ft. of gas per hour per horse-power, or about 5,200 cubic feet per month. Giving gas at $1.50 per thousand (and in many places it is much lower than this), the gas engine will deliver power at a cost of $7.80 per month per horse-power. We can, without much trouble, obtain the $9.37 rate per month for a motor in competition with the gas engine, on account of its many and obvious advantages, but we can seldom obtain the $13.80 rate. This maximum capacity rate also very much hampers the user in a selection of a motor, and the motor salesman, in order surely to effect a sale, is very apt to underrate the prospective load on the motor, as the customer is governed in his purchase of a machine much more by the monthly charge than by the first cost of the motor.

Another feature which must not be lost sight of is the fact that a motor user who has bought and paid for his machine becomes your permanent customer, his income being entirely derived from the product of the work of his motor. His bills for power you are also sure of collecting, for the moment his power is shut off his earning capacity ceases. The motor becomes to him an absolute necessity instead of a seasonable luxury, as is the case with many electric lights.

* Abstract of a Paper read before the National Electric Association, Cape May, August, 1890.

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Another very remarkable feature brought out by these diagrams is the fact that the average power consumed in doing serviceable work is but three-eighths of the total power used, and the remaining five-eighths (68%) is consumed in driving shafting. This enormous loss in shafting would indicate that the day may not be far distant when each machine will be equipped with its own direct-geared motor, and that the days of shafting and belting are numbered.

RESEARCHES ON THE PRODUCTION OF LIGHT BY ANIMALS AND VEGETABLES.*

BY RAPHAEL DUPOIS.

My object in the present researches has been to study the effects produced by the electrolysis of salt water rendered phosphorescent, either by mixing with it photogenic substances extracted from luminous animal tissues, or by luminous micro-organisms. I made particular use of the luminous mucus of the dactyle pholas, diluted with salt water. The luminous liquid was introduced into a U-shaped tube, the legs of which contained platinum electrodes, connected to a battery sufficiently powerful to electrolyse salt water. As soon as the water began to decompose, the light, after having slightly increased at the positive pole, began to get dimmer and dimmer, and was finally completely extinguished. The same phenomenon occurred at the negative pole, where the light persisted only at the surface of the liquid in contact with the air. The light was first extinguished in the portions of the tube occupied by the electrodes, but the process of extinction soon spread all over it, except at one point where there remained a luminous disc. This point was at the end of the positive electrode, and just where the electrolytic discoloration of some turnsole poured into the tube stopped. Since my last published researches upon the dactyle pholas, I have convinced myself that if this mollusc does sometimes contain luminous symbiotic micro-organisms in its syphon, which, at first, caused me to believe in the existence of a soluble ferment in the mucus secreted by this organ, it also possesses a luminosity proper, whose seat is the layer which I have described as the neuro-conjunctive layer. The photogenic tissue is not limited to the Polian vescicles, and these do not deserve the name of luminous organs as proposed by Panceri, although the light is more intense there than anywhere else. They are, as I have pointed out elsewhere, secretive organs, which seem intended, amongst other things, to evacuate migratory elements covered with rounded granulations (*vacuolides*). I have recognised that these migratory elements are the actual agents of the luminosity proper of the pholas, which must be distinguished from the symbiotic or parasitic luminosity.

These facts are easy to explain. In fact, I have already shown that we can extinguish either the luminous micro-organisms or the photogenic substances extracted from phosphorescent animal tissues by slightly acidulating the medium, and that we can restore their luminosity by making the medium alkaline again. Moreover, it has long been known that oxygen and water are necessary factors in the manifestation of luminous effects in animals and vegetables. Under the influence of electrolysis the medium becomes acid at the positive pole, and the light is extinguished at this point in spite of the abundance of oxygen and even ozonised oxygen which is liberated. At the negative pole it is the nascent hydrogen which produces extinction either by displacing the oxygen or as a reducing agent, although the medium is alkaline. The truth of this interpretation of the phenomenon can be shown by allowing a drop of liquid ammonia to fall into the extinguished solution of luminous mucus at the positive pole, when the light will immediately reappear. The same result ensues at the negative pole, when a little air is blown in by means of a fine tube. The experiment is somewhat more difficult when photogenic microbes are used instead of the mucus of the pholas. If the luminous liquid has been extinguished, either by a strong acid or by heat, in spite of the liberation of ozonised oxygen at the positive pole, and in spite of the alkalinity developed at the negative pole, the light does not reappear in any portion of the tube, even when liquid ammonia is added and air is insufflated. It is very difficult after this to assert that this light is merely an oxidation phenomenon ; and I am of opinion that it is rather a true respiratory effect, which can only take place in an alkaline, oxygenated and aqueous medium.† But in the luminous liquid obtained by diluting the phosphorescent mucus of the dactyle pholas with salt water there are, after filtration, no cellular elements at all, but only round granular bodies which are met with in all luminous tissues. Panceri considered them to be grease-like drops. This, however, does not agree with my own observations, which lead me to believe that they are protoplasmic granulations endowed with an obscure vitality like certain ferments. I have named these bodies *vacuolides* for reasons which I have given at length elsewhere.* They are due to dissociation of cellular protoplasma, which can be brought about by direct excitation, and seen with the eye in the ectodermic tissue of the Hippopodius Gleba.†

In electrolysed luminous liquids, the following phenomena are observable :—At the negative pole a scum is formed consisting principally of *vacuolides*. On the other hand, at the positive pole one meets, especially in the case of the mucus of the pholas, with those refracting, radio-crystalline granulations which take the place of the *vacuolides* in all tissues which have ceased to be luminous. In liquids rendered luminous by micro-organisms, these granulations are especially numerous at the positive pole, and the *vacuolides* at the negative pole.

To sum up, the researches which I have now made for several years lead me to definitely assert that the production of light is connected in the case of animals and vegetables with the transformation, under the influence of a respiratory phenomenon, of the colloidal protoplasmic granulations into crystalloid granulations.‡ In the first portion of my studies on photogenic phenomena, I had the mechanism more particularly in view, and I was able to supplement our knowledge and correct some errors. As to my investigations on the fundamental and general cause of the phenomenon, they have frequently led me to premature interpretations which I have been obliged more or less to abandon, as new facts showed their insufficiency. In judging my previous interpretations, however, I hope it will be remembered that they relate to experiments on a living substance, which can never be manipulated in large quantities, nor at all times and places.

AN EFFICIENCY TEST OF THE THIRD WARD RAILWAY AT SYRACUSE, N.Y.§

BY G. D. HULETT.

As will be remembered by many, about a year ago Dr. Louis Bell made a test of the Sprague electric railway at Lafayette, Ind., and found that the all-day efficiency was but 25 per cent.** The greater part of the loss occurred in the station itself, as the electrical horse-power delivered to the line was but 41 per cent. of the horse-power of the engine. The latter was a Hamilton-Corliss of 130 horse-power, which drove a line shaft, and belted to this were two Edison shunt-wound generators of 30,000 watts capacity each, which supply the car-line. The results seem to indicate that slow speed engines are ill-fitted to the requirements of street railway work with its constant and sudden variations of load ; and it was Dr. Bell's opinion at the time that the conditions of maximum efficiency would be brought about by the use of high-speed engines belted directly to the generators, which should be compound wound.

The present test was conducted upon the Thomson-Houston road at Syracuse, New York, some time ago by Mr. S. J. Larned and the writer, then students at Cornell University. This road is about four miles in length, connecting Geddes or West Syracuse with the centre of the city, and at the time of the test operated seven cars. The power is furnished by two Armington and Sims engines, each of 80 horse-power, to which are belted two compound-wound Thomson-Houston generators of 60,000 watts capacity, which are run in parallel. The equipment is thus seen to be far more than adequate for seven cars, and at present there are several more in operation. For this reason, therefore, the efficiency will be found rather low.

The test naturally divides itself into three fairly well-defined steps :—1st. To obtain the efficiency of the station. 2nd. The efficiency of the line. 3rd. The efficiency of the cars. The ratio $\frac{\text{E.H.P.}}{\text{I.H.P.}}$ was found by choosing favourable moments once about every 25 minutes, when the current remained constant for a few seconds, and then reading ammeter and voltmeter, while cards were taken from the engines. At the same time an attempt was made to have the mean E.H.P. computed from these readings agree as closely as practicable with that obtained from the recording instrument and mean voltage for the day. In this we succeeded very well, as the mean E.H.P. was 34·1 and

* From the *Comptes Rendus*, Tome CXI., No. 8.

† It is known that luminous tissues, or dried particles extracted from these tissues, may be preserved a long time without loss of photogenic power by keeping them in contact with the air, a fact which can always be tested by means of a drop of water.

* See *Les Vacuolides* (Soc. de Biol., March, 1887).

† *Loc. cit.*

‡ By using tubes of close porous earth, one always stops the luminous particles, and all my efforts to isolate a definite chemical substance capable of glowing spontaneously in air have failed. I have not, therefore, been able to cross the line which separates this biological phenomenon from a regular chemical action.

§ From the *Electrical World* of New York.

** See *Electrician*, July 5 and 12, 1889.

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32·3 respectively. The efficiency of the station was thus found to average 62·8 per cent., which may be considered very good when we reflect that nearly double the number of cars could be operated with the same equipment. The highest efficiency observed was 82 per cent. when the I.H.P. was 108, the highest reading taken. As the I.H.P. was frequently below 30, and the resulting efficiency little above 40 per cent., and sometimes below, it is evident that even when run to its full capacity it is doubtful if the station efficiency would ever rise above 75 per cent.

The efficiency of the line calculated from voltage readings taken at the station and on the line simultaneously was found to average about 91 per cent.

The efficiency of the cars is rather a difficult thing to ascertain. The practice in the Thomson-Houston system is to throw out the whole of the rheostat as soon as practicable after starting, and consequently fully ¼ths of the entire distance traversed by the car is covered with the motor running at its maximum efficiency. This is certainly true at Syracuse, where the conditions are favourable for long runs without a stop in the thinly peopled district lying between Syracuse and Geddes. The method adopted was to find the maximum efficiency of an average car, with the external resistance entirely thrown out, by obtaining the work necessary to cover 350ft. upon the level track and the same distance upon a grade averaging 5·76 per cent. By combining the results of these observations, this efficiency was found to be 75·8 per cent. This shows up very well for the motors when we recollect that some 10 per cent. is consumed in the gearing. The efficiency of the car with the rheostat arm in other positions can be computed in the same manner, and then the all-day efficiency estimated from these results and the considerations mentioned in the beginning of the paragraph. In the present case 65 per cent. was taken to represent this mean efficiency, as closely as obtainable from the data at our command.

The efficiency of the entire system may, therefore, be found by taking the product of the efficiencies of station, line and cars, or $62·8 \times 91 \times 65 = 37$ per cent. Comparing this with the 25 per cent. obtained at Lafayette, as has been stated, it is seen that high-speed engines belted directly to the generators have a decided advantage over the slower running Corliss engines, which also must waste a considerable amount of power in a line shaft.

The coal consumption was 5,500 pounds. But steam was supplied to an adjacent shop from 7 a.m. to 6 p.m., and deducting 700 pounds as the equivalent amount used there, we have 4,800 required by the railway. The average horse-power for the day was 51·4, hence the coal per indicated horse-power hour was 5·3 pounds, and per electrical horse-power hour 8·4 pounds. Were the plant run up to its normal capacity these figures would be considerably reduced. As the cars ran 98 miles per day the electrical horse-power hours per car mile are easily computed and found to be ·82.

One point incidentally noticed in taking voltage readings upon the line was that the curves consumed more power than the grades. The lowest voltage observed upon the heaviest grade was 381, while 360 was read when rounding a curve upon a slight incline, and again while a car between the test car and the station was passing round the same curve. Since the drop in voltage is mainly due to the resistance of the line, the demand for current must have been very great. The practice of keeping the curves lubricated is a good one, for the friction is thus much reduced.

The mean voltage at the station was 487, although it frequently ran up above 500 and fell below 470. The greatest current was 225 amperes, and 200 was observed several times; but in all cases these large currents were held at the longest but a few seconds before a drop occurred.

REVIEWS.

Electric Light Fitting. A Handbook for Working Electrical Engineers, embodying Practical Notes on Installation Management. By JOHN W. URQUHART, author of "Electric Light," &c. (London: Crosby Lockwood and Son, 7, Stationers' Hall-court, Ludgate-hill, 1890.)

A demand has arisen for good plain text-books on practical details, and this Mr. Urquhart has attempted to provide at a price within the reach of all. "Electric Light Fitting," Mr. Urquhart's latest addition to the literature of electricity, is designed to serve as a companion to "Electric Light" by the same author, a little work which reached its third edition last November. This volume consists mainly of the every-day notes of a working electrician. It deals with what may be termed the mechanics of electric lighting, and is addressed to men who are already engaged in the work, or are training for it. The author assumes that his readers are familiar with the general principles of the science of electricity, and with the subject matter of his volume on electric lighting: the present work may be read as a sequel to it. Although small, it traverses a great deal of ground. The general scope of this book includes central station work, the localising of dynamo faults, observations respecting accumulators, switch-board and testing-work, systems of arc-light wiring and fitting, incandescent lamp wiring, and the lighting of ships. The text contains much miscellaneous matter, and deals with some of the practical difficulties ordinarily met with by the working electrician. Mr. Urquhart's aim is to produce elementary books which make no endeavour to assist the mathematical study of the science of electricity. At the same time, it is to be hoped that no one who reads them will be content with the smattering of knowledge which he has acquired, but will be incited to study the subject in a more thorough manner, and with the aid of an author of wider experience.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 22, 1890.

National Electric Light Association.—The semi-annual Convention of the National Electric Light Association has just been held at Cape May, New Jersey. The active members of this Association are all central-station men, and as a result many interesting Papers relating to the details of central-station work, in theory and practice, are brought before it. The meeting occupied three days, and was full of interest to the members in attendance. The first morning session brought out one Paper of importance to central-station men in particular, as well as to political economists. It was read by Mr. M. J. Francisco, who dealt with the subject of Municipal Lighting. During the past few years Mr. Francisco's attention has been specially directed to the economical details of central-station management by municipalities; and the results he has reached have been the product of a very elaborate study. His Paper took up in detail municipal lighting in nearly every town in the United States that has tried it. The official reports usually show preposterously low expenses for such plants; and the author's investigation was in large part devoted to examining critically the conditions that produce such presumably favourable effects. It became very evident that the economy in such cases is only apparent, for the reason that municipal accounts do not show under the proper heading the real expenses of electric lighting. It is found in nearly every case that very important items of expense are either unaccounted for or are found charged to other departments than that of electric lighting. By reason of this the apparent expenses of municipal plants are very low, while the real expenses are in nearly every case higher than those of a plant conducted by a private corporation. Apparently, the real fact is that municipal plants are made to a greater or less extent subject to political jobbery, and consequently are not conducted on a proper commercial basis.

A second Paper that attracted great attention at the Convention was one by Mr. Lufkin on "The Proper Basis of Determining Electric Motor Rates." The author, the electrician of a large motor company, had to examine in detail the output of a large number of installations operating all kinds of machinery for very varied sorts of work. The figures showed that even the maximum load required by the work to which a motor is put is generally considerably below the capacity of the machine; in other words, that an unnecessarily large motor has been installed. If, then, the rates charged for supplying power to such motors are based on nominal horse-power, the charges would be necessarily excessive; and Mr. Lufkin laid down the proposition that the proper basis for charge was the maximum load required of the motor, quite irrespective of its normal capacity. This quantity can be readily determined by measurements of a simple enough character, and furnish a legitimate commercial basis for charge. Metering electricity for motor use has not yet come into very extensive use in this country, but several prominent central stations have adopted the method suggested, and find it very satisfactory both to themselves and to their customers. The details of the Paper give a great deal of very valuable information as to the actual

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power required to operate various sorts of machinery, and form a most excellent basis for judging the proper size of motor to put in a given manufacturing establishment. Another interesting point brought out was the large amount of power consumed in the shafting usually employed in connection with motors. In many cases it would probably result in real economy to connect the motor directly to the given machine by coupling or belt. This plan, by the way, is carried into practice to a very large extent in the great factories of the Thomson-Houston Electric Company, at Lynn, Mass., where a very large number of separate machines are driven by individual motors with excellent results for economy.

A brief and very suggestive Paper was presented by Mr. Williams on "The Use of Triple Expansion Engines for Central Station Work." The author laid down the proposition that on the whole such machines would be found to give very satisfactory service, and the decreased consumption of fuel would in most cases pay for the extra cost of the more complicated engine in a single year. The cost of triple-expansion engines in this country is about 20 per cent. greater than that of ordinary compound engines; but the saving in fuel is usually found to be something like 20 per cent., so that there is a very considerable advantage to be derived from their use.

The committee work of the Association proved to be decidedly valuable, and efforts are being made to collect data concerning various problems that arise in central station operation. Efforts will be especially made to secure full details as to cost of generating power, a subject which has not yet received the attention that its importance demands.

A large number of members were in attendance, and in connection with the other work of the Convention many exhibits were shown of various devices and appliances used in central-station work. Most of the prominent electric supply companies were represented; and this feature of the Convention was, as it has been in past meetings, of considerable advantage. The meetings of the National Electric Light Association have resulted in some very interesting conferences between representatives of various interests more or less directly connected with electrical work. Especially at the present meeting was an effort made to secure co-operation on the part of the various insurance companies with reference to electrical risks. The committee on this subject was unable to make its final report, but some progress has been made toward formulating a general set of rules. The subject is, of course, a difficult one, but it is hoped that by the next Convention a code will be brought forward which will meet the approval both of the insurance companies and of those immediately interested in electric lighting. We have now various rules for installation in force in different parts of the country, and it is highly desirable that these should be reduced to a uniform basis, so that there may be some authoritative statement of the precautions to be taken in installing electric plants.

An interesting set of rules was brought forward at the meeting by Prof. Henry Morton, at the instance of the Employers' Liability Insurance Company, dealing especially with the precautions to be taken for the safety of workmen. These rules were of a most practical character, and were heartily endorsed by the members of the Association as likely to be of considerable value in future work, and as tending to promote the welfare of *employés*. The Convention was on the whole a successful one. A great amount of valuable work was accomplished, and plans were laid for still further widening and increasing the usefulness of the Association to all branches of electrical industry.

CORRESPONDENCE.

ELECTRICAL DRILLING MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am much surprised to find, on page 454 of your issue of August 29th, a paragraph which professes to give a description of an electrical, or rather electro-magnetic, drilling machine, devised by Mr. Willatt, of Earle's Shipbuilding and Engineering Company (Limited), Hull, but which really describes a modification of the special class of electromagnetic machines for drilling and similar operations which I patented in 1882, and have introduced successfully since then.

You were good enough to publish extensive illustrations of some of my designs in your issue of June 3rd, 1887, and other illustrations have appeared in the *Engineer* and other papers from time to time; so that such publicity has been given to them as would fairly entitle me to believe that no person interested need have been ignorant that such machines had been devised.

I have further ground of complaint against this attempt to appropriate my designs and to take the credit of my invention, in that my friends, Messrs. McWhirter, Ferguson and Co., of Govan, who have manufactured several of my machines, supplied to Earle's Shipbuilding Company, in May last, a photograph and full particulars of one of my drillers, in reply to an inquiry addressed to them by Earle's Company.

I do not believe that the paragraph in your issue of last week is inserted with the sanction of the General Manager or the Board of that Company, and am, indeed, surprised that anyone should lend his name to so barefaced an attempt to appropriate the brains of another man.

My drillers, having electromagnets for attaching themselves to a curved deck, have been doing exactly the work you describe since January last in French shipbuilding works on some Japanese cruisers being built there, and have recently been introduced on the Clyde for similar work. In other forms they—as well as tapping and other machines on my system—are also doing a variety of other work on ships and boilers successfully.

You can understand from this that I am prepared to maintain my claim to this invention.—Yours, &c., F. J. ROWAN.

Regent Chambers, 121, West Regent-street,
Glasgow, September 1, 1890.

[The paragraph to which our correspondent alludes was taken from a local paper. We presume that most of our readers are aware of the inventions of Mr. Rowan, and many of them are no doubt acquainted with the ingenious methods which he has employed in carrying them out. We have no information as to the comparative merits or priority of the patents of the two drilling machines, and cannot therefore judge as to any intention to infringe or as to the "barefaced attempt to appropriate" our correspondent's brains.—ED. *E.*]

ELECTRICAL NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. Fleming has raised the question respecting the nomenclature of the various units used in electrical measurements; and, in common with many others, he objects to the unit of self-induction being called either a Secohm or a Quadrant, and at the same time he calls attention to the fact that other units have distinguished physicists as their sponsors. To carry this system of baptism a step further, I venture to suggest that the unit of self-induction be in future designated as the "Flem."—Yours, &c., B. A. M.

British Association, Leeds, September 3, 1890.

TRADE NOTES AND NOTICES.

REMOVAL.—We understand that Messrs. Nalder Bros. and Co. are removing their factory from Westminster to No. 16, Red Lion-street, Clerkenwell, owing to increase of their business. The new premises will allow for considerable extension of their manufacture of voltmeters, ammeters, and other instruments, and the testing department will be on the same premises instead of at a distance as at present.

DISSOLUTION OF PARTNERSHIP.—The partnership has been dissolved which lately existed between Messrs. W. Mackie and Chalmers, electrical engineers, of Turnmill-street, Clerkenwell, E.C.

TENDERS DUE.—Tenders for the Electrical Central Station in Stockholm will be received from September 15th until October 12th, 1890, addressed to the direction of gasworks in Stockholm.

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MAXIM-WESTON ELECTRIC LIGHT COMPANY (IN LIQUIDATION).—The liquidators of this Company invite tenders for the purchase of all machinery, plant, and stock, in one lot, at the Company's works, Kingsland Green, Dalston, N.E. Tenders, endorsed "Tender for Works," are to be in by September 15th next. Further particulars will be supplied by the Secretary of the Company, 55, Victoria-street, Westminster, S.W.

MESSRS. ERNEST SCOTT AND CO.—This firm have obtained the contract for the complete electric light installation for the new flour mill at Dunston, being built by the Co-Operative Wholesale Society. This mill will be one of the largest in the kingdom, if not the largest, and the electric light plant, which is being put in in duplicate, will consist of two 400-light "Tyne" compound-wound dynamos, and 466 16 candle-power incandescent lamps. The arc light installation will consist of one 9-unit "Tyne" compound-wound dynamo, and ten "Tyne" arc lamps, in strong water-tight lanterns, with reflectors. We hear that Messrs. Ernest Scott and Co. have a considerable quantity of work in hand of all descriptions, including a large contract for the lighting of Messrs. Arthurs and Co.'s works in Glasgow, in which two 400-light "Tyne" dynamos will be used. They are also lighting Messrs. John Bright and Bros.' Mills, at Rochdale, the new works of the *Bolton Evening News*, and the Cold Meat Rooms of the Northern Counties Ice Company.

SHIP LIGHTING.—The contract for lighting the four new steamers for the Manchester, Sheffield, and Lincolnshire Railway Company has been given to Messrs. Paterson and Cooper. Two of these are being built by Earle's Shipbuilding Company, Hull, and two by Swan and Hunter, Newcastle. Messrs. Paterson and Cooper have on hand besides the above the lighting of the ss. "Innamincka," "Garnet," "Tuskar," "Arranmore," "City of Dundee," and H.M. training ship "Empress."

THE WENHAM COMPANY (LIMITED).—This Company have recently carried out several important installations—among others, the Dental Hospital, Leicester-square, and the new theatre and winter gardens at Craig-y-nôs Castle, for Madame Patti-Nicolini—which have given their clients and the insurance companies great satisfaction. The theatre contains in all about 220 lamps, and there are also a number of suspended lamps in the winter gardens.

MESSRS. PAGE AND MILES.—This Company have lately completed an installation for Mr. G. Russell Miller, of Burgess Hill, Sussex, in which they have used an "Infant" dynamo with very satisfactory results. The dynamo is a 200 watt shunt-wound machine, and is driven by a Crossley two-man gas engine. This is principally engaged in charging a set of E.P.S. accumulators, but will run direct or in parallel with the cells if required.

MESSRS. EARL AND PHILP.—The tender of this firm, whose business address is 113, London-wall, E.C., has been accepted for lighting and ventilating the new premises of Mr. I. Kino on Ludgate-hill. The amount of the tender was £375.

ASBESTOS FIREPROOF CURTAINS.—The United Asbestos Company have received a letter from the lessee of the Queen's Theatre, Manchester, recently destroyed by fire, stating that, "Although for a long time the extent of the fire on one side of the curtain was so great that it must have been red hot, it remained intact, and the stage was saved, and the stage stock uninjured." This was the first occasion on which a "Victor" metallic drop curtain has been severely and practically tested, and justifies the claim of the Company as to its fireproof character.

THE AUTHOR'S HAIRLESS PAPER PAD.—We have received, and have almost used up, a very handy block of scribbling paper, sold under this title by The Leadenhall Press. A very light wooden holder to fit it is very convenient when writing in the train or in an arm chair. The back is of thick blotting paper, and each sheet when written can be placed underneath, the ledges on the wooden holder keeping them together.

CRICKET.—WOODHOUSE AND RAWSON UNITED (LIMITED) v. APPLETON, BURBEY AND WILLIAMSON.—A cricket match between elevens representing the above firms was played on Saturday last at Raynes Park, which, after an exciting game, ended in a victory for the former by one run. Scores:—Woodhouse and Rawson United (Limited).—First innings, 133; second innings, 58; total, 191. Appleton, Burbey and Williamson.—First innings, 94; second innings, 96; total, 190.

COMPANIES' MEETINGS & REPORTS.

Brush Electrical Engineering Company (Limited).

First annual report, to be presented to the shareholders at the general meeting of the Company to be held at Cannon-street Hotel, London, on the 8th September, 1890, at 12 o'clock noon:—

The Company was registered on the 10th August, 1889, and the business of the Anglo-American Brush Electric Light Corporation (Limited) was taken over as from the 1st August, 1889, and that of the Falcon Engine and Car Works (Limited) as from the 14th June, 1889, and the accounts made up to the 30th June last are for the periods embraced by these dates. The arrangements for carrying on the business of the Australasian Electric Light and Power Company (Limited) were not completed until much later, and the accompanying accounts do not include any return of business effected by the Australasian branch.

The profit and loss account shows a gross profit of £36,698. 16s., and after deducting all standing charges, maintenance of plant and buildings, and interest on debentures, there remains a balance of £14,235. 6s. 1d. It is proposed to apply £625 to reduction of preliminary expenses, £500 to reduction of provisional orders account, and £3,000 to reduction of property, patents and goodwill account to meet depreciation under these heads. The net balance of £10,426. 19s. 3d. is available for dividends. An interim dividend absorbing £3,808. 6s. 10d. has already been paid upon the Preference shares for the six months from August 10th to February 10th last, and it is proposed to apply £3,505. 4s. 6d. to the payment of a further dividend upon these shares, making up the full preferential dividend at the rate of 6 per cent. per annum from the date of registration of Company to June 30, 1890. The Directors recommend that the balance of £2,796. 14s. 9d. be carried forward to next account.

The temporary interruption to business caused by the amalgamations with other Companies and extensions of works has to some extent adversely affected the profit and loss account; and as several months have necessarily to elapse before the new works at Loughborough could be completed, the advantages of the lower cost of production at the country works were not obtained in regard to a large proportion of the orders executed. In view of all these circumstances, Directors consider the result of the year's working as encouraging.

The Falcon works at Loughborough have been considerably enlarged during the year at an expenditure of about £20,000; and the extension of these works enables the Company to manufacture at a materially reduced cost engines, boilers, cars and electrical machinery of practically every description and size. The Directors are of opinion that this money has been well spent, and they anticipate good results in the future from the erection of these works.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN
PHOSPHOR BRONZE.

PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.

SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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It affords the Directors much satisfaction to state that the Bill confirming the Provisional Order for lighting the central division of the City of London has been passed by Parliament. The agreement with the Commissioners of Sewers of the City of London provides that the work for the purpose of public lighting shall be commenced within nine months from the 21st May last, and the Directors are making the necessary preparations for giving effect to this condition.

The Company has also obtained a Provisional Order for Bournemouth, where a central electric light station has already been erected, which promises to yield very satisfactory returns. The Directors have applied to the Board of Trade for Provisional Orders for several other towns in the United Kingdom where the Company has interests to protect.

The Austro-Hungarian businesses have developed in a satisfactory manner, and the Vienna factory shows improving results both as to volume of trade and as to net profit. The necessity for providing additional factory accommodation in Vienna has now arisen, and the Directors are concluding negotiations for the acquisition of some freehold land and buildings adjoining the present works. They have also under consideration proposals for a re-arrangement of the Company's interests in the Vienna business.

The Directors have, with the assistance of Captain Rowan, the late general manager of the Australasian Company, fully examined into the character of the business acquired from that Company, and have made arrangements for the proper development of the Company's valuable patents and organisation in the Colonies.

Messrs. Cooper, Brothers and Co., the auditors, offer themselves for re-election.

The transfer books of the Company will be closed until after the 9th inst.

NEW COMPANIES REGISTERED.

LAMP MANUFACTURING COMPANY (LIMITED).—Registered, with a capital of £16,000, in £1 shares. Object: To carry into effect, with or without modification, an agreement which is already prepared and expressed to be made between Ridsdale's Railway Lamp and Lighting Company (Limited), of the first part; Edward Cecil Moore, the official liquidator of the said Company, of the second part; and Peter E. Chalton, of 18, Saltoun-road, Brixton, as trustee for the Company, of the third part; to carry on business as manufacturers of and dealers in lamps of all kinds.

NEW COMPANIES REGISTERED DURING AUGUST.—The following new electrical and engineering companies were registered during August:—

	Capital.
Atlas Engine Company (Limited), £1 shares	£12,000
Ceres Ironworks (Limited), £10 shares	15,000
Gordon Electric Traction Syndicate (Limited), £10 shares	2,400
Lartigue Railway Construction Company (Limited), £1 shares	125,000
Lamp Manufacturing Company (Limited), £10 and £1 shares	16,000
Mills's Patent Sectional Boiler Company (Limited), £5 shares	100,000
Nickel Steel Syndicate (Limited), £10 shares	75,000
Nonpareil Electrical Syndicate (Limited), £10 shares	6,000
Square Drilling Machine Company (Limited), £1 shares	100,000
Store's Patent Submarine Engineering Company (Limited), £1 shares	6,100
Sheffield Telephone Exchange and Electric Light Company (Limited), £1 shares	100,000
Vaughan-Sherrin Electrical Engineering Company (Limited), £5 shares	25,000

SHEFFIELD TELEPHONE EXCHANGE AMD ELECTRIC LIGHT COMPANY (LIMITED).—Registered by J. B. Roberts, 12, Coleman-street, E.C., with a capital of £100,000, in £10 shares. Objects: To acquire the undertaking of the Sheffield Telephone Exchange and Electric Light Company (Limited) (incorporated September 11, 1888), and to carry on in the United Kingdom or abroad all or any of the businesses of forming, establishing, and conducting telephonic and electric exchanges or centres, and of dealers in and leasing or letting of telephones and telephonic apparatus and wires. The first subscribers are:—John Tasker, Geo. Senior, Geo. Franklin, William Johnson, T. G. Shuttleworth, R. Charles Tasker, and William Tasker. There shall be not less than three nor more than six Directors. The first are John Tasker (Chairman), Joseph Gamble, George Senior, George Franklin, and William Tasker. Qualification, 20 shares. Remuneration, £300, divisible.

CITY NOTES, &c.

BANKERS' AND MERCHANTS' TELEGRAPH COMPANY OF NEW YORK.—The property and franchises of this Company have been recently sold at auction under foreclosure. Colonel Robert G. Ingersoll bid it in for $390,000.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 29th amounted to £4,806.

COMPAGNIE NATIONALE D'ELECTRICITE.—The public subscription to the share-capital of this Company, which works the Ferrante system in France, has enabled the company to commence immediate operations both in Paris and in the provinces.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of August were £2,900, as compared with £2,815 in the corresponding month of last year. The receipts for the month of May, estimated at £3,400, realised £3,409.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of August amounted to £2,075, as compared with £1,624 for the corresponding period last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of August, 1890, amounted to £52,606, and to £52,012 in the corresponding period of 1889, an increase of £594.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for August amounted to £46,526, as against £39,469 in the corresponding period, showing an increase of £7,057.

ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED).—The *Financial News* of September 3rd devotes an article to the subject of the value of the shares of this Company, for which, it appears, that the plant now in process of completion is estimated to yield a profit of £174,720 per annum, sufficient to enable the Company to pay a dividend of 100 per cent. and leave a large surplus. Mr. Elmore himself is credited with the statement that the shares of the Company, although now standing at only £7, will at no very distant period stand at £50 each. If the various reports which are in circulation can be taken as correct, there must be a good time coming for Elmore shares.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in August, 1890, £25,000; 1st January to 31st August, 1890, £181,000; corresponding months, 1889, £178,200; corresponding months, 1888, £179,200.

TRUSTEES, EXECUTORS, AND SECURITIES INSURANCE CORPORATION (LIMITED).—This Corporation announces that it will pay off the whole of its £200,000 first mortgage four-and-a-half per cent. debentures on March 1, 1891, at the rate of 110 per cent.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The Traffic Receipts of this Company for the month ending 31st August, 1890, amounted to £4,950.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended August 29, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,772.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended August 31st, amounted to £2,420, compared with £2,161 in the corresponding period last year, an increase of £259.

WINFIELDS (LIMITED).—The Directors of this Company in their report just issued announce that, notwithstanding the reduction of the capital of the Company, they are still unable to recommend the payment of any dividend to the shareholders. They propose to raise £25,000 in £100 Debentures, and solicit the co-operation of the shareholders in their efforts to place the Company on a sound footing.

THE NON-CONDUCTOR OF ELECTRICITY.

VULCANISED FIBRE,

PATENTED.

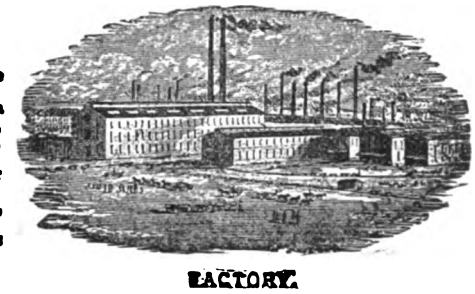
This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 2ft. 6in., varying in thickness from 1-50in. to 1in.



FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Aug. 27.	Price Wednesday, Sept. 3.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 3.	
£						£ s. d.		Highest.	Lowest.
			TELEGRAPHS.						
1,381,380	Stock	15/0	Anglo-American	50⅛ 51⅛	51 52	5 5 9	Jan., Apr., July, Oct	50 ..	
2,809,310	Stock	30/0	Do. Preferred	87⅛ 88⅛	87⅛ 88⅛	6 4 4	,, ,, ,,	88⅛	87⅛
2,809,310	Stock	..	Do. Deferred	15½ 15⅝	15½ 15⅝	..	..	1 5⅛	13⅛
25,000	£100	4%	African Direct, 4 per Cent. Debentures	97 100	97 100	4 0 0	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	5 6 1	Mar., June, Oct., Dec.	12	11¾
69,200	100	5%	Do. 5 per Cent. Bonds	100 102	100 102	4 18 0	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103 107	103 107	4 13 6	June and December	..	..
..	$100	..	Commercial Cables	102 104	103 105	..	..	103⅜	..
16,000	£10	9/0	Cuba Submarine xd	12½ 13	12½ 13	6 10 9	February and August	..	..
6,000	10	10%	Do. Preference 10% xd	16½ 17½	16½ 17½	5 14 3	,, ,,	17½	16½
12,931	5	5½% 1889	Direct Spanish (£4 paid)	3⅜ 4	3⅜ 4	5 10 0	March & September	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October..	..	..
60,710	20	3/6	Direct United States	10½ 10⅝	10½ 10⅝	6 13 4	Jan., Apr., July, Oct.	10⅝	10⅜
400,000	10	5/6	Eastern	13⅜ 14⅛	13⅜ 14⅛	4 12 0	,, ,,	14⅛	14
70,000	10	6%	Do. 6 per Cent. Preference	15 15⅛	15 15⅛	3 17 5	,, ,,	15⅛	15
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	106 109	105 103	3 14 1	May and November	105	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	108	..
250,000	10	2/6	Eastern Extension	14 14½	14 14½	4 18 3	Jan., Apr., July, Oct.	14½	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100 102	100 102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	100 103	100 103	4 17 1	,, ,, ,,	..	..
180,227	10	4/3	Globe Telegraph and Trust	8⅞ 9⅛	8⅞ 9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅝ 15⅛	14⅝ 15	4 0 0	,, ,, ,,	15	14⅞
150,000	10	5/0	Great Northern	15⅝ 16	15⅝ 16⅛	4 12 4	Jan., April, and July	16⅛	16
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100 103	100 103	4 17 1	January and July ..	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	106 109	104 107	4 18 6	March & September	..	..
17,000	25	37/6	Indo-European	37 39	37 39	6 7 2	April and October ..	..	..
38,348	10	4/0	London Platino-Brazilian	6 7	6⅛ 7⅛	..	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures xd	107 110	105 108	5 11 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅞ 8⅛	7⅞ 8⅛	6 1 3	April and October..	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	113 117	113 117	5 2 7	,, ,,	..	..
15,609	£10	6/6	West African	9 10	9 10	5 0 0	.. ..	..	..
200,000	100	5%	Do. 5 per Cent. Debentures xd	100 103	99 102	4 18 0	March & September	100⅛	..
30,000	10	3/0	West Coast of America	3 4	3⅛ 4⅛	..	January and July ..	3⅛	3⅛
150,000	100	8%	Do. Debentures 8%	103 108	101 106	7 10 11	June and December	104⅛	103⅛
88,321	10	Nil.	West India and Panama	2⅞ 3	2⅞ 3⅛	..	..	3	..
34,563	10	6/0	Do. 1st Preference 6%	11½ 11⅝	11⅛ 12	5 0 0	April and October..	11⅝	11⅛
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	13 14	13 14	4 5 9	.. ..	..	..
64,572	15	6/0	Western and Brazilian	11⅛ 11⅜	11 11⅛	5 5 3	May and November	11⅜	11⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅞ 7⅛	6⅞ 7	..	..	6⅞	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	4⅞ 5⅛	4⅛ 5	..	..	4⅞	..
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103 106	103 106	5 13 2	.. ..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101 104	101 104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120 125	120 125	5 12 0	May and November	..	..
175,100	£100	6%	Do. 6 per Cent. Sterling Bonds xd	99 101	97 99	6 1 3	March & September	..	..
			TELEPHONES.						
224,350	14/0	0/5⅛	Consolidated Telephone Const. and Maintenance	⅝ ¾	⅝ ¾	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	⅜ ½	⅜ ½	4 8 3	Yearly	⅜	..
436,700	5	3/0	National	4⅛ 5	4⅛ 4⅜	6 3 1	June and December	4⅜	4⅛
15,000	20	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12 12½	12 12½	4 16 0	June and December	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10 10½	10 10½	4 11 9	,, ,,	..	..
209,750	1	½%	South of England, Ordinary	½ ⅝	½ ⅝	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd).	2⅛ 3	2⅛ 3	6 19 11	.. ..	..	..
55,000	5	1/0	United River Plate	3⅛ 4⅛	3⅛ 4	..	January and July ..	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	.. ..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..	..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	1⅞ 2⅛	1⅞ 2⅛	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4 4⅛	4 4⅛	..	..	4⅛	..
42,858	5	..	Westminster Electric Supply	1⅛ 1⅜	1⅛ 1⅜	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	2	..	Brush Electrical Engineering	1⅞ 2	1⅞ 2	..	..	..	..
63,416	2	1/2	Do. Preference	1⅞ 2	1⅞ 2	..	..	1⅞	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5⅛ 5⅜	5⅛ 5⅜	6 1 9	.. ..	..	..
353,478	5	..	Edison and Swan United	..	..	..	..	..	..
409,000	10	..	Electric Construction	7⅜ 8⅛	7⅜ 8⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	7 7⅛	7⅛ 7⅜	..	..	8⅛	7
20,000	5	..	Fowler-Waring Cables	2 2⅛	2 2⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18⅛ 19⅜	17⅛ 18⅛	5 8 1	February & August	18⅛	18⅛
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	.. ..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5 5⅛	5 5⅛	3 16 5	..	5⅞	5⅝
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	42 44	5 9 3	March and July.....	43⅛	42⅛
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 102	100 102	4 18 0	..	..	..

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(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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THE ELECTRICIAN:

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NOTES.

The most important communication at the Meeting of the British Association this year, so far as electrical science is concerned, was undoubtedly that of Prof. Ewing on "A Molecular Theory of Induced Magnetism," whose contribution to the current number of the *Phil. Mag.* on this subject will be found in another column. Among the congratulations and expressions of admiration which followed the discourse, the assertions that this was the most important discovery of this year and that it ranked with those of Hertz were not due to mere temporary enthusiasm. The illustrations in the author's Paper give a very inadequate idea of the beautiful experiments which it would be almost impossible to describe, and which must be seen to be appreciated. We hope that Prof. Ewing will be induced to repeat them under conditions more worthy of the occasion, and before an audience of ten times the size, at some institution in London. Besides the magnetic theory of Prof. Ewing, the meeting of the British Association at Leeds in 1890 will not be memorable for anything which concerns electrical engineering.

The work of the Sections commenced on Thursday with the Presidential Addresses. In Section A Dr. Glaisher did not attempt the usual, and generally unsatisfactory, task of reviewing the progress of his own subject—pure mathematics, or of that of the Section for the preceding 50 years, or since the British Association last met at Leeds; but delivered an address which surprised even those who know the special branch of mathematics to which he has devoted himself. Ranking as he does as one of the four great pure mathematicians of the day, he gave in his address, of which we give a brief abstract, an excellent account of the relations which mathematics bear to physics. Specialising in a subject which seems to most people to be the extreme sublimity of arithmetic, although he says that the theory has nothing to do with arithmetic in the ordinary sense of the word, his division of the theory of quantity into two branches only, "Algebra, and all the ordinary subjects of pure mathematics," and "the theory of numbers," is not remarkable. It is an excellent thing that mathematics should be so specialised. Some minds are mathematical, and some are not; exactly as some are musical and others find neither pleasure or any interest in melody or harmony. But there are still a number of engineers, and even men of science, who, believing mathematics to be "the ordinary processes of algebra, differential and integral calculus, &c.," imagine that they are not mathematically minded, and therefore avoid those branches in which such operations are required. The day is happily approaching when geometrical methods are being more commonly used; and such persons are beginning to realise that some subjects, at all events, are open to them in which they can surely arrive at solutions of problems without having to translate them first into a language of symbols, thence to be re-translated into common sense.

The discussion which was announced for Friday morning on Electrical Units was very disappointing. Mr. Glazebook read a valuable Paper describing the different methods by which the ohm had been determined, and gave a very complete list of the results, pointing out the relative merits of the various systems, especially with reference to the various degrees of accuracy with which the different quantities could be measured and the form in which they appear in the calculations. It is difficult, for example, to measure the exact mean radius of a coil, and it is therefore desirable that the diameter should not appear as a square, but as its first power. The Paper by Prof. Viriamu Jones was of great interest; but the discussion, except so far as it related to the methods, was very poor. The general question of the use of mercury was raised; and there appeared to be a general opinion among most of those who have been engaged in carrying out the work of making the determinations, that mercury was the proper material of which to make the standard. It was admitted that such a standard was quite unsuitable for engineers, Lord Rayleigh saying that it was useless for factory purposes, a wire being what was really wanted. The fact is that practical men are in the hands of the higher beings who carry out the experiments. The comparison of a wire with the mercury standard is a sufficiently difficult operation, and quite beyond the powers of any ordinary engineer and of most instrument makers.

It was proposed in a very formal manner that the meeting should determine whether the value of 106·3 should be adopted. It was pointed out that since the United States were represented by Prof. Rowland, and France by Prof. Mascart, the question might receive an international sanction. This ambitious idea unfortunately fell through, as Prof. Rowland was unprepared with any figures, and Prof. Mascart had apparently gone to lunch. No one but a Surgeon-Major, whose name we did not catch, raised any objection. Mr. Preece, who justified his reluctance to adopt the value pro-

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posed four years ago, unhesitatingly accepted the average of the latest determinations, and undertook to recommend the adoption of 106·3 to the Government. At a subsequent meeting of the committee this value was adopted by the British Association.

For the Paper by Mr. Wilson Hartnell, the author substituted a lecture "On the Stringency of Fire Office Rules," illustrating his remarks by experiments. He had provided a number of glow lamps and switched them on gradually, with a single No. 20 wire in circuit, until 50 amperes were passing. The wire then began to burn. The same current was then passed through a No. 16 wire, raising it to about 90 degrees. We are able to state upon the highest authority that the point of the author's arguments was altogether missed; and, therefore, without further comment, we refer our readers to the Paper, which will be reproduced in our columns.

Among the examples of the want of organisation was the reading in Section G, on Monday, of the Paper by Mr. Newman Laurence, and Dr. Harries, on the physiological effects of currents, another being down for reading by Mr. Swinburne in Section A, on the same subject. This is by no means a rare occurrence, and is an instance of the careless way in which the business is arranged. The discussion on the former did not bring to light any useful information.

An artificial retina sensitive to light in the same way as the average human eye is certainly a great desideratum in photometry; and, according to M. Lion, this may be obtained by the use of a moist film of iodide of nitrogen. A new photometer, based on the employment of this substance, was described in the Notes column of our last issue, and since the longer the film is subjected to the action of the light rays the greater is the quantity of nitrogen disengaged, the sensibility of the instrument must continually increase with the time of exposure. This characteristic forms a decided advantage which the instrument possesses over others; but its significance is much diminished by the fact that it appears to take a considerable time before sufficient nitrogen is disengaged to take a reliable reading. In spite of the fact that the chemical action of light is caused chiefly by the non-luminous or ultra-violet rays, it appears that with this substance the luminous rays are most effective, and that, just as with the human eye, the yellow green rays have the greatest influence. Considering the well-known fact that human eyes differ considerably among themselves, and that partly in consequence of this photometric measurements are subject to many errors, it would appear that the film of iodide of nitrogen can be regarded as an artificial retina, measuring illumination equally well, whatever its colour. If a substance of this nature can be found which may be left to itself without danger, and from whose indications reliable readings may be obtained without the need of waiting some minutes, its applications to photometry would be numerous and important; and with this view it seems desirable that the action of light on complicated chemical compounds should be studied further than has hitherto been the case.

For some time past there have been reports of a very unsatisfactory character with regard to the performances of the electric light at Bath, but we were inclined to attribute them in a large measure to local exaggeration of those minor mishaps which seem to be the inevitable concomitants of electric lighting stations in this country when they first come into operation. The letter of Mr. Charles Powell, which will be found in our correspondence columns, shows, however, that things at Bath are not as they should be, and that the breakdowns are due to causes well within human control. In A.D. 1890, "experimental lighting" should be as extinct as the dodo.

In our correspondence columns this week will be found two interesting communications from Prof. Elihu Thomson with regard to some recent editorial comments of ours upon his new meter and new alternator.

Telegrams for South America.—We are informed that the cable from Buenaventura to Santa Elena has been repaired.

Platinum.—It is reported that platinum has been discovered in some ores from the Las Yedras Mines in the State of Sinaloa.

Teplitz.—The Town Council has decided not to renew their contract with the Gas Works, but to build an electric light station.

Woolwich.—The Woolwich Local Board has decided to support the proposed Order of the Woolwich District Electric Lighting Company.

Derby.—At the last meeting of the Town Council an Electric Lighting Committee was appointed to take into immediate consideration the question of carrying out the provisions of the Electric Lighting Order just granted to the Corporation.

Zurich.—The Zurich municipality intend, says *Industries*, to arrange with the Oerlikon Works for the street and private lighting of the town. The installation will be for 10,000 lamps of 16 c.p. Brockie-Pell lamps will be used for the arc lighting.

The Zanzibar—Dar-es-Salaam Cable.—The Eastern Telegraph Company's ss. "Amber" completed on 10th instant the laying of cables from Zanzibar to the German stations at Bagamoyo and Dar-Es-Salaam under agreement with the German Government.

Ayr.—On the recommendation of the Committee, the Town Council has agreed to appoint Messrs. Muir, Mavor, and Coulson to report as to the best system of electric lighting for Ayr, and to give plans and full statistics as to the cost of erection and maintenance of works.

Glasgow.—At the last meeting of the Town Council it was decided that a remit should be made to the Gas Committee to consider, under such professional guidance as they might think necessary, the whole subject of carrying into effect the powers contained in the Corporation Electric Lighting Order.

Electric Light in the Hofburg.—The Emperor of Austria has decided that the electric light shall be introduced into his palace in Vienna, the Hofburg, where till now wax lights have generally been employed for the purpose of illumination. About 8,000 incandescent lamps will be required to light the building throughout.

Bristol.—The Sub-Committee appointed to visit various towns to inspect the methods adopted for supplying electricity for lighting purposes have recommended that the Corporation shall take the electric lighting into its own hands, and suggest that some 70 1,000 candle-power arc lamps shall be erected in the main streets.

Tempered Copper.—Amongst the electrical exhibits at the Cape May meeting of the National Electric Light Association were some tempered copper castings. Samples were shown of

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commutator segments, dynamo brushes, rolled copper for brushes, spring rolled copper, journal bearings, and copper castings of various kinds.

The Australasian Cable Rates.—*The Times* states that the New Zealand Government has declined to bear a share of the subsidies and guarantees required by the cable companies in connection with the proposed reduction of the telegraph rates between Australia and Great Britain, owing to the refusal of the Imperial Government to bear any portion of the responsibility.

Electrical Litigation.—The Victor Popp Company, says the *Bulletin International de l'Electricité*, used to number amongst its customers the Café Chauvet. Owing to the unsatisfactory character of the supply, however, the proprietor recently decided to give up the use of the electric light, and has now brought an action against the Popp Company for the purpose of obliging it to place his fittings in their original condition.

A Diminutive Electric Light and Power Station.—Collias, near Nimes, a village of 465 inhabitants, has just been lighted by electricity. The motive power for the 1,600-light dynamo is derived from a small waterfall. The streets are lighted by 25 lamps of 16 candle-power each. Besides lighting the village, the current is employed during the day in putting in motion the pumps for supplying certain parts of the village with water.

Personal.—We are informed that Major-General Webber's Paper on "Electrical Distribution," which he had purposed reading before Section G last Monday, was withdrawn owing to the Committee having felt that the subject was too comprehensive to permit of its being adequately discussed in the time available. Major-General Webber intends to bring his Paper before the Institution of Electrical Engineers at an early date.

Dundee.—At the last monthly meeting of the Dundee Gas Commission, Mr. Henry Robertson stated that with a steadily increasing consumption of gas the Board were apt to remain quiescent in regard to electric lighting, but he hoped the Board would not delay in providing the community with the light of the future. A letter was then read from the Electric Installation and Maintenance Company tendering its services for the construction and maintenance of electric works in Dundee.

Morse Signalling at Night.—On Monday night last experiments were conducted in the Solent with a new electric signalling lamp, under the superintendency of Captain Gallwey, of the Hecla. The Mastiff, Blazer, Seahorse, and a torpedo boat were stationed at fixed distances apart, stretching from Bembridge Ledge to the shore, and after dark a number of flashing signals were exchanged with the object of determining the range at which the Morse code could be distinguished and read.

Wanton Destruction of Telegraph Insulators.—At the Manchester Police Court on Monday, five youths were each fined 40s. and costs for destroying telegraph insulators. For some time the habit of smashing insulators has been growing amongst the lads in the suburbs of Manchester, with the result that since January over 400 have been broken in one district. One of the witnesses stated that in his district alone the cost of repairs by the damage to insulators was close on £1,000 per year.

The British Association Meeting.—The *Yorkshire Evening Post* of Wednesday contains a humorous illustrated description of what the Editor terms "The Farewell to the Philosophers." Some grotesque caricatures from the pen of Mr. Harry Furniss are given; included in the list being Sir Douglas Galton, Sir Frederick Abel, Sir William Thomson, Lord Rayleigh, Sir Henry Roscoe, Sir Frederick Bramwell, Prof. Glaisher, &c. Humorous text accompanies the illustrations, and this is followed by some poetry on the work of the Association.

Magnetic Brass.—We have recently had an opportunity of examining sheet-brass compass cases, which exhibited distinct traces of magnetism. In some the polarity was weak and somewhat irregular and ill-defined, but in one in our possession the poles are strong and well defined, and this phenomenon is doubtless due to the presence of iron particles within the brass, although we should add that the cases in question were supplied by a good maker. It would be interesting to know whether instrument makers and others have often met with this "magnetic brass."

Fareham.—An experimental run of the electric light was made on Friday night over a portion of the system by the Fareham Electric Light Company. The main streets, from the railway station to Wallington Hill, a distance of about a mile and a quarter, are to be lighted by 21 arc lamps of 1,200 candle-power, and the side streets are to be illuminated by about 85 incandescent lamps, each of 20 candle-power. The Company's contract with the Local Board, who have engaged to pay £500 per annum for the lighting of the town, came into effect on Monday.

Edinburgh Exhibition.—The East of Scotland Engineering Association recently held a special session at the Exhibition. Amongst the Papers read was one on the "Protection of Buildings from Lightning," by Mr. A. R. Bennett, Vice-President of the Association, in which the effects of several recent storms in Scotland on buildings and telegraph wires were described; and one descriptive of the telephonic exhibits, by Mr. C. G. Wright. The remaining Papers dealt with the mechanical exhibits, the one by Prof. Elliot on the Locomotive Annex being specially noteworthy.

The Seely Flexible Wired Moulding.—The Seely "flexible wired moulding" is of rubber, and in this moulding the wire is imbedded. The moulding corresponds to ordinary wooden moulding, and answers exactly the same conditions, as well as having a number of advantages of its own. It can be placed on ornamental ceilings and walls without defacing them, and will take any decorative finish required. It can be handled in rolls of several yards, cut to any needed length, and carried right to the spot, with the consequent avoidance of carting, and the cutting, sawing, &c.

A Sign of Progress.—One of the most characteristic signs of the progress which is being made by electricity is, says *La Lumière Electrique*, to be seen in the rapidly increasing size of the dynamo units adopted at central lighting stations. At the Electrical Exhibition of 1881 the most powerful dynamo was an Edison machine giving 800 amperes and 110 volts (120 horse-power). At the present moment the Berlin central stations have 500 horse-power dynamos running, and at Deptford a 3,000 horse-power alternator is at work and two 10,000 horse-power machines are building.

The Water Power of the United States.—"An official calculation upon the best data obtainable brings out the extraordinary fact," says the *Electrical Engineer* of New York, "that the rivers and streams of the United States, averaged throughout the year, show over 200,000,000 horse-power." The returns of the 1880 census showed that there were in use in the United States no fewer than 55,404 water-wheels, developing a total of 1,225,379 horse-power, or 36 per cent. of the total power employed for industrial purposes. In 1880, therefore, only ·6 per cent. of the total available water-power of the United States was utilised.

Georgetown (Demerara).—The Telephone Exchange—to which there are already 200 subscribers—was inaugurated on August 1st. All business places are required to pay an annual rental of $24, and private residences a subscription of half the amount, one month's notice being required of intended discontinuance. At present 27 of the Government Office are on the list of renters, as well as the Town Hall, Waterworks, and three other Municipal Offices, 95 business firms, including the Railway, Gas Company, and Ice depôts, and 73 private residences. The whole of the arrangements are in charge of Mr. S. Vyle, the Government Electrician.

Tasmanian Telegraphic Statistics.—The last report of the Tasmanian Telegraph Department shows a steady increase in business. The number of messages increased in 1889 from 70,453 in the previous year to 77,408, and the revenue from £4,801. 17s. 4d. to £5,378. 3s. 3d. The lines during the year were extended 47 miles, and five new offices were opened. The miles of poles on December 31, 1889, numbered 1,283, miles of wire 1,889, stations in circuit 120, persons employed

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184. During the year 43,087 free messages were transmitted, valued at £4,530. 3s. The total number of messages passing through the Hobart office during the year was 79,163. The rental received from telephones during the year was £3,108. 14s. 5d., as compared with £2,640. 18s. in the previous year.

The Gassner Dry Cell.—In a letter to the *English Mechanic* Mr. G. E. Bonney gives some particulars relating to an experiment which he carried out to test the durability and recuperative capabilities of the Gassner dry cell. The cell employed was of the flat square type, measuring $6\frac{1}{4} \times 3\frac{1}{4} \times 1\frac{1}{4}$in. The cell was connected up to a 2in. bell and run on it day by day, stopping only at night. The recuperative effect of a night's rest on the cell was most marked. When 118 hours' work had been got out of the cell it was determined to recharge it. To effect this it is only necessary to connect the positive pole of a two-celled Bunsen battery to the negative pole of the Gassner cell, and send a current through for a few hours, to thoroughly renew its vigour.

The Lemp Transformer for Heavy Currents.—When transformers are designed to produce very large currents, as in electric welding operations, the question of winding the secondary becomes a difficult one. In the Lemp transformer the secondary is a solid mass of copper, having a groove in its side, in which lies the primary coil. By this arrangement the secondary can be made as a single casting and the primary wound over it, or, in some cases, wound on a bobbin and slipped over it. The secondary thus consists of a single turn of a great cross section and consequently enormous carrying power, while the construction of the transformer is rendered exceedingly simple. Transformers of this type have been made at the works of the Thomson Electric Welding Company, and have proved very convenient and efficient.

The Frankfort Exhibition.—Messrs. Siemens and Halske are putting down continuous and alternating current plant on a very extensive scale at the Exhibition, as well as a huge battery of accumulators. Two tramways, one worked by accumulators, the other by an overhead conductor, will convey passengers to the Schillerplatz. Inside the Exhibition a tramway with underground conductor will also be shown. For running various workshops Messrs. Siemens and Halske are transmitting power by electricity from a source four kilometres distant at the Palmengarten. The deposition of copper and the commercial production of ozone are to be shown in the metallurgical and chemical sections. In the telegraphic section will be a tape-printing machine, which, it is said, has not yet come into extensive application in Germany.

University College, Nottingham.—The classes about to commence at this College in electrical and mechanical engineering, for both day and evening students, will practically cover the same ground as those at Finsbury, and will prepare evening students for the City and Guilds technological examinations, and for the Government and Whitworth Exhibitions. The College is provided with a three-light Brush and 300-light Ferranti dynamo, with Siemens's exciter, &c., driven by a Roby steam-engine. In the new dynamo-room the newest type of Atkinson Cycle gas engine, specially fitted for tests, &c., drives a Phœnix dynamo that can be joined up in various ways. For the mechanical course, a well-provided mechanical engineering laboratory is being arranged. The new technical schools, to be erected at a cost of £15,000, for the engineering department, besides being the headquarters of the various courses in engineering proper, are intended to support the local industries, lace and hosiery, and meet the local needs.

Electric Lighting at Reichenhall, Bavaria.—The motive power for the Reichenhall central station is obtained from a stream, the quantity of water available being about 4,000 to 4,500 litres (140 to 157 cubic feet) per second, with a fall of 2·6cm. (8·8ft.). Jonval constant-speed turbines, running at 34 revolutions a minute, are employed, and drive Kapp alternators through intermediate shafting. The alternators have an output of 2,000 volts and 30 amperes at 600 revolutions. The mains, which are of 6mm. copper wire, run overhead on masts 50ft. high, Johnson and Phillips' insulators being used. The circuit runs through the town of Reichenhall to the cloister of St. Zeno, about two miles away, and thence to the Kirchberg and other distant localities. At present 10 Kapp transformers, having a total output of 43,000 watts, are installed. The transformers are provided with three terminals to enable the consumers to run either 50 or 100 volt lamps. Some 900 incandescent and 118 arc lamps have already been connected to the mains.

Barnsley.—At a meeting of the Town Council, on Tuesday, the minutes of the Park and Lighting Committee were discussed. The committee recommended that the Town Clerk should be directed to apply to the Local Government Board for their sanction to borrow the sum of £23,000, required for electric lighting purposes. The committee also recommended that Mr. Bromley Holmes be appointed electrical engineer during the construction of the electric lighting plant, and also for three months after its completion. Mr. J. H. Bailey moved that the clause with respect to the appointment of Mr. Bromley Holmes be adjourned to next month; and he raised the question whether they had, in the Westinghouse Company, whose tender the Council had decided to accept, the best system that could be got. He moved that the minute referred to be adjourned, and that the Thomson-Houston Company be allowed to send in an amended tender. A long discussion ensued, and ultimately the minutes were confirmed, subject to the last clause being adjourned one month. Mr. Bailey then gave notice that he would at the next meeting propose that the resolution of the Council accepting the Westinghouse tender be rescinded.

A Mascart Dynamometer.—In a recent number of the *Comptes Rendus*, M. Mascart describes a direct-reading transmission dynamometer with photographic recording-apparatus devised by him. The following abstract of his description is taken from the Foreign Abstracts of the Institution of Civil Engineers. On the shaft of the prime mover are mounted two pulleys, one fast the other loose. The latter is connected to the former by springs, the deformation of which is indicated by a pointer playing over a scale on one of the pulleys. The scale is empirically graduated. When the movement is slow, the position of the pointer can be determined by inspection; but for quick-running shafts, M. Mascart increases the time during which the pointer is visible, by adding to it a lens so placed that the pointer is in its focus. The pointer and corresponding mark on the scale remain then visible during the time that the shaft requires to revolve through an angle equal to the focal angle of the lens. The image of the pointer can be photographed on a slip of sensitised paper set in movement by the shaft. M. Mascart states that the dynamometer described has been fitted to a 10-HP. steam-engine at the Central Meteorological Bureau.

The Safety of Electricity.—The vague and irresponsible statements which have for a long time past been circulated, more particularly by the daily press, have had the effect, says The *Electrical Engineer* of New York, of instilling into the minds of the uninformed the notion that the *employés* of electric-light stations were subject to greater risks from accidents than those engaged in any other occupation, powder mills and dynamite factories not excepted. All attempts to counteract this feeling of distrust have heretofore been futile; and it is, therefore, a matter for congratulation that the electrical fraternity is now enabled to go before the public with a statement of the exact facts, in the shape of statistics gathered by an Insurance Company, whose desire to get at the correct figures cannot be called in question. The result of the investigation undertaken by the Employers' Liability Assurance Corporation, as set forth in Prof. Morton's Paper, read at Cape May, shows that out of 91 accidents reported in central stations only 15 were assignable to the effects of the current, the remaining ones being such as are constantly occurring in power-using establishments.

Telegraphic Statistics.—According to the New York *Tribune* there are in use now throughout the world 2,500,000 miles of land telegraph wires. Of the sum total of lines, those of the United States constitute a little more than 30 per cent. Sixty-one per cent. of the telegraph lines of the world are owned and operated by Governments, and leaving the United States out of consideration, about 88 per cent. In North America the

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body of the message only is charged for; in other countries the address or signature, or both, are tollable. In the United States the toll ranges from 25c. to $1 for ten words, according to the distance; in the Argentine Republic it is 40c. for ten words, and 20c. for each additional ten words; in Denmark and in Sweden and Norway, 13·4c. for ten words, and 1·34c. for each additional word; in Ecuador, 20c. for ten words; in Egypt, 49·6 for ten words; in Germany, 1·4c. per word, the minimum being 14c. per message; in the United Kingdom, 6d. for twelve words; in the Cape Colonies, 1s. for ten words, and 6d. for each additional five words or part thereof; in Italy, 20c. for fifteen words, and 1c. for each additional word; in Japan, 4c. per word, including the address and signature; in Portugal, 5c. for the first word, and 1c. for each additional word; in Switzerland, 1½c. per word; in Turkey 2c. to 4c. per word. In New Zealand messages are classified as urgent, ordinary, and delayed, the rates being respectively 2s., 1s., and 6d. for ten words, with ½d. for each additional word.

Electrolysis of Animal Tissues.—A Paper on this subject by Mr. G. N. Stewart is being published in a volume of memoirs from the physiological laboratory of the Owens College, Manchester. The first part of the research was directed to answering two questions:—Is the conduction in animal tissues entirely or chiefly electrolytic? What are the electrolytes? It is shown that by far the greatest part of the conduction at any rate is electrolytic, and that the best conductors are undoubtedly the inorganic constituents of the tissues. The proteids are exceedingly bad conductors. It is shown that the proteids are affected not by primary electrolysis, but by the products of electrolysis of the salts. In solutions of coagulable proteids alkali-albumen is formed at the cathode, and acid-albumen at the anode, some of the proteid being coagulated at the latter. Great changes were found in the microscopic appearance of the fibres of isolated tissues, suggesting the action of a dilute acid. At the cathode the fibres were more homogeneous than before. There was no indication in the electrolysis of blood that hæmoglobin acts the part of an ion. At the anode the reaction becomes acid, and acid-hæmatin is formed, which remains partly in solution and is partly thrown down, the solution becoming less deeply coloured. When the current is strong, or long continued, the hæmatin suffers further change and is decolorised, apparently by the oxygen or chlorine set free. The proteids of the serum and corpuscles are partly coagulated at the positive pole.

The Gibbs System of Train Lighting and Heating.—In some of the express trains running on the lines of the Chicago, Milwaukee, and St. Paul Railway Company, the Gibbs system of lighting and heating has been in successful operation for nearly two years. An independent "light and heat tender," in other words a central light, heat and power station on wheels, is attached to the train. This special car follows immediately behind the locomotive tender, it is 34ft. long by 9ft. in width, and is encased in ¼in. plate steel. Including full equipment, the car weighs about 29 tons. The interior is divided into two compartments, separated from each other by steel doors. The forward section contains a tubular steel boiler of the locomotive type, with water leg around fire-box. The rear section contains a No. 4 Edison compound-wound dynamo belted direct to a standard Westinghouse engine of 15 horse-power, the distance between the centres of shafting being 7ft. 6in. The weight of engine and dynamo is counterbalanced by a steel tank placed on the opposite side of the section, and holding 270 gallons of water in reserve for use in the event of an accident or the absence of the locomotive tender, from which the water required in the boiler is constantly pumped. Experience has shown that when the thermometer falls to 10°F. above zero, it requires 100lb. of water per car hour to properly heat the train, and 70lb. of water per car hour of the temperature is only 5° below freezing point. In addition about 58lb. of water are required per indicated horse-power hour in the operation of the dynamo. An idea of the efficiency of the system may be drawn from the results of a recent test, which show that for 48,000 watt-hours supplied in the lamps, 68 horse-power hours were supplied to the dynamo. The commercial efficiency of the system is therefore about 94 per cent.

Street Lighting of New York.—With reference to the high prices asked by the electrical supply companies for street lighting of New York, the *New York World* learns that every subway connection to an arc light costs the company $100 (£20. 18s.), and the subway rental amounts to from 5½ to 11 cents (2¼d. to 5d.) a night for each lamp. One circuit averages nearly 11 cents rental for each lamp. In this circuit there are six and four fifths miles of cable, the actual cost of which was $182.50 (£38) for each lamp. This, added to the cost of connections, lamps, and other expenses, brings the total preliminary outlay up to $322 (£67) per lamp. As the city will only make contracts for one year this expenditure may all be a dead loss. The relative cost of dynamo stations, machinery, &c., is about $400 (£83. 10s.) for each lamp. Interest and taxes on this total preliminary outlay of $722 (£150) per lamp will amount to 10 per cent., or $72.20 a year. The actual cost for coal, labour, &c., to generate the current amounts to an average of 26 cents nightly for each lamp. A cable will not last over ten years, if so long. Adding 10 per cent. of the cost of the cables for the actual running expenses, and interest and taxes on capital invested, brings the actual expense per lamp up to $223.18 (£46. 10s.) a year. At 35 cents (1s. 6d.) per night for each city lamp the companies would receive $127.75 (£26. 10s. about) a year, or $95.43 (£20) less than the actual cost, and in the estimate of cost officers' salaries and some other necessary expenses are not included. The New York companies this year offered to light the lamps for the same as last year up to January 1st and for 43 cents (1s. 9d.) after that. The reason given for this is that there was only about $70,000 (£14,600) left for street lighting. A few years ago the city paid 45 cents a night for each lamp, and found that price cheaper than hiring extra policemen.

Electrical Gear for Quick-Firing Guns.—The Forges et Chantiers de la Mediterranée are making great use of electrical power, not only in their Toulon shops, but for working the Canet quick-firing gun. For training in elevation, a small electric motor is placed on a bracket bolted to the rear of the left-hand frame of the carriage and forming an extension of it; the armature runs on a horizontal shaft. On this is mounted a bevel wheel that gives motion to suitable gearing, and to a spindle that actuates the elevating gear. For training horizontally, a second small motor is employed. In both cases a clutch is interposed in such a manner that, by shifting a lever, the electrical arrangement can be thrown out and the ordinary hand gear substituted. The motor that supplies the energy for training in elevation weighs 61·6lb; that for training in direction, 72·6lb. The difference of potential adopted is 70 volts, which is the standard in use in the French Navy for electric lighting. At the Paris Exhibition, where an electrically-equipped Canet quick-firing gun was exhibited, recourse was had to accumulators, Commelin-Desmazures cells being employed. These accumulators, it will be remembered, consist of copper and zinc plates placed in an alkaline bath; the positive plate is formed of porous copper, and the negative of a metallic cloth made of tinned iron wire. The bath consists of a concentrated solution of zincate of potash. During the charge the porous copper is transformed into a sub-oxide of copper, and the zinc is deposited on the iron gauze, the potash remaining free in the solution. During the discharge the zinc is restored to the potash solution; the sub-oxide of copper is reduced, and is restored to its original condition of porous copper. The plates so arranged do not require any preliminary formation. At the Exhibition the installation used for furnishing power to work the gun consisted of 45 cells, each of which gave about ·75 of a volt. Especially interesting in this arrangement is the facility given for training both in direction and elevation at the same time, as it is obvious that the work of laying the gun can be carried out far more promptly, and the rapidity of fire can be thus largely increased. It is evident, says *Engineering*, to whom we are indebted for the above particulars, that if electrical power can be relied upon, and the disadvantages attending its use overcome, that it presents great advantages as regards first cost and ease of maintenance and control, as compared with water power. It seems, indeed, most probable that the departure exhibited by M. Canet last year will have larger consequences than he imagined at the time when he designed the apparatus for electrically raising, lowering, and turning his 15-centimetre quick-firing gun.

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ON ALTERNATE CURRENTS IN PARALLEL CONDUCTORS OF HOMOGENEOUS OR HETEROGENEOUS SUBSTANCE.*

BY SIR WILLIAM THOMSON, F.R.S.

This Paper consists of a description of some of the results of a full mathematical investigation of the subject, which I hope to communicate to the *Philosophical Magazine* for an early number :—

1. Two or more straight parallel conductors, supposed for simplicity to be infinitely long, have alternating currents maintained in them by an alternate-current dynamo or other electromotive agent applied to one set of their ends at so great a distance from the portion investigated that in it the currents are not sensibly deviated from parallel straight lines. The other sets of ends may, indifferently in respect to our present problem, be either all connected together without resistance, or through resistances, or through electro-motive agents. All that we are concerned with at present is, that the conductors we consider form closed circuits, or one closed circuit, and that therefore the total quantities of electricity per unit of time at any instant traversing the normal sections in opposite directions are equal.

2. We suppose the period of the alternation to be very great in comparison with the time taken by light to traverse a distance equal to the greatest diameter of cross-section of our whole group of conductors. This supposition is implied in the previous assumptions of parallel rectilinearity of the electric stream lines, and of equality of the quantities of electricity traversing, in opposite directions, the several areas of a normal section.

3. We farther suppose that the length of our conductors and their effective ohmic resistances are so moderate† that the quantities of electricity deposited on and removed from their boundaries to supply the electrostatic forces along the conductors required for producing the alternations of the currents, are negligible in comparison with the total quantity flowing in either direction in the half-period. This supposition excludes important practical problems of telegraphy and telephony, the problem of long submarine cables, for instance ; but it includes the problem of electric lighting by alternating currents transmitted at high tension through considerable distances ; as, for example, from Deptford to London.

4. The general investigation includes as readily any number of separate circuits of parallel conductors as a single circuit, but, for simplicity in describing results, I suppose our system of conductors to be so joined at their ends as to constitute a single simple circuit of two parallel conductors.‡ It may be either two parallel conductors or one conductor, one of which may or may not surround the other, as shown in Figs. 1 and 2, representing cross-sections. Each conductor may be single as in Figs. 1 and 2, or either may be multiple parallels.

5. We suppose each conductor to be homogeneous in substance, and in cross-section from end to end, but not necessarily homogeneous in different parts of the cross-section. Thus the two conductors, or the different parts of either, may be of different metals, or either conductor or any part of either conductor may consist of two metals (as iron and copper, or iron and lead) laid parallel and soldered together.

6. We shall call A and A′ the cross-sectional areas or groups of areas of the two conductors respectively of the other. All the different portions of A are connected metallically at their two ends, and are thus all of them at one potential at one end and another potential at the other end ; and similarly for A′. The homogeneousness of the material and of the cross-sections along the length of the conductors and the uniformity of the total currents assumed in § 3, implies that all the different parts of A in one cross-sectional plane are at one potential, even though A consist of mutually isolated parts, or A′ consist of isolated parts. If, as in Figs. 1 and 2, all the parts of A are in mutual metallic connection, and all the parts of A′ are in mutual metallic connection, this would entail uniformity of potential through A, and uniformity of potential through A′, even without the limitation of our subject laid down in § 3.

7. The following are some of the most noteworthy results of the full mathematical treatment of the subject.

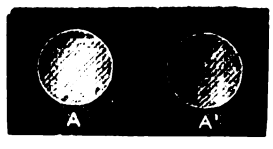

Fig. 1.

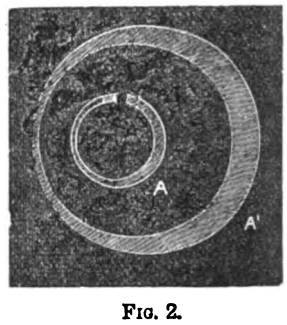

Fig. 2.

I. When the period of alternation is large in comparison with 400 times the square of the greatest thickness or diameter of any of the conductors, multiplied by its magnetic permeability, and divided by its electric resistivity, the current intensity is distributed through each conductor inversely as the electric resistivity ; the phase of alternation of the current is the same as the phase of the electro-motive force ; and the current across every infinitesimal area of the cross-section is calculated, according to the electro-motive force at each instant, by simple application of Ohm's law.

II. When the period is very small in comparison with 400 times the square of the smallest thickness, or diameter of any of the conductors, multiplied by its magnetic permeability and divided by its electric resistivity, the current is confined to an exceedingly thin surface-stratum of the conductors. The thickness of this stratum is directly as the square root of the quotient of resistivity, divided by magnetic permeability, of the substance in different parts of the surface. The total quantity of the current per unit breadth of the surface is independent of the material, and, except in such cases as those referred to at the end of II. below, varies in each cross-section in simple proportion to the electric surface density of the static electrification induced by the electro-motive force applied between the extremities for maintaining the current. The distribution of this electric density is similar in all cross-sections, but its absolute magnitude at corresponding points of the cross-section varies along the length of the conductor in simple proportion to the difference of electric potential between A and A′, and is zero at one end, in the particular case in which the conductors are connected through zero resistance at one end, while the electromotive force is applied by an alternate current dynamo at the other end. On the other hand, the surface distribution of electric current is uniform throughout the whole length of the conductors, and it is only its distribution in different parts of the cross-section that varies as the electric density.

* Author's abstract of a Paper read before the British Association, in Section A, Leeds, September, 1890.

† The circumstances in which this condition is fulfilled may be usefully illustrated by considering the important practical cases of submarine cables, and of metallic circuits of two parallel wires insulated at a distance anything less than a few hundred times their diameter. For all these cases the numeric expressing the electro-static capacity of either conductor per unit of its length (the other supposed for the moment to be at zero potential) is between 2 and 0·1, and for our present rough comparison may be regarded as moderate in comparison with unity. On this supposition the condition of the text requires for fulfilment that the mean proportional between the velocity which expresses in electro-magnetic measure the resistance of one of the conductors and the velocity of a body travelling the length of the conductor, in a time equal to half the period of alternation, shall be exceedingly small in comparison with the velocity of light.

‡ The case of a single circuit made up of parallel conductors, so joined at their ends that to travel once round it we must go and come two or three or more times along separate conductors, joined by their ends in series, so as to make one circuit, is specially considered in my Paper on "Anti-Effective Copper in Parallel or in Coiled Conductors for Alternating Currents," to be communicated presently to Section A.

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The proportionality of surface intensity of the current to electric density, asserted above, fails clearly in any case in which the circumstances are such that the distance we must travel along the surface to find a sensible difference in electric density is not very great in comparison with the thickness of the current-stratum. Such a case is represented in Fig. 3, which is drawn to scale for alternate currents of period $\frac{1}{80}$th of a second in round rods of copper of six centimetres diameter. The spaces between the outer circular boundaries and the inner fine circles indicate what I have called the mhoic thickness,* being 714 of a centimetre for copper of resistivity 1611 square centimetres per second. The full solution for such a case as that represented in Fig. 3 belongs to the large class of cases intermediate between I. and II., and could only be arrived at by a kind of transcendent mathematics not hitherto worked. But without working it out, it is easy to see how the time-maximum intensity of the current will diminish inwards from the surface, and will be, at any point of either of the inner fine circles, about one-half or one-third of what it is at the nearest point of the boundary surface; and that at points in the surface, distant from B B′ by one-half or one or two times the mhoic thickness, the current intensity will be much smaller than it is at B B′.

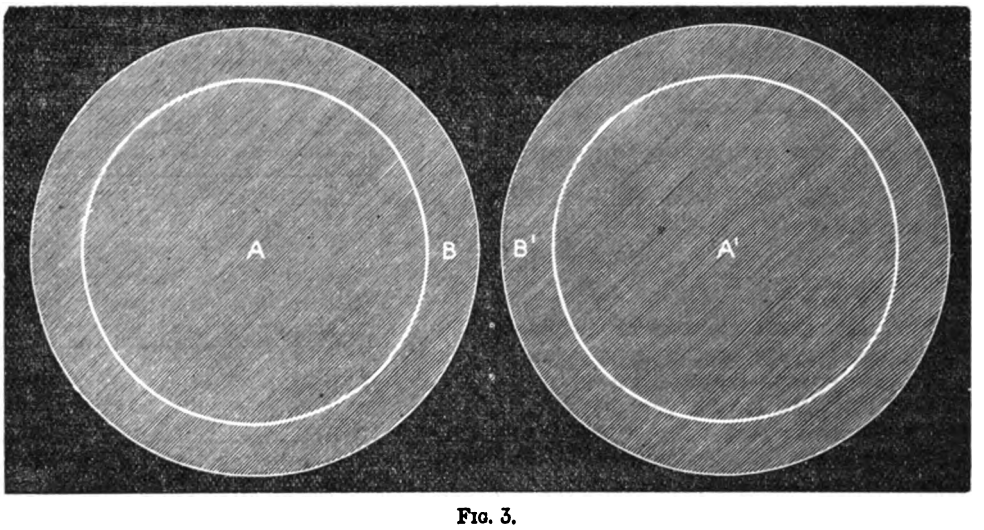

Fig. 3.

III. In Case I. the heat generated per unit of time, per unit of volume, in different parts of the conductors, is inversely as the electric resistivity of the substance, and directly as the square of the total strength of current, at any instant. In Case II. the time-average of the heat generated per unit of time, per unit of area of the current stratum, is as the time-average of the square of the quantity of current per unit breadth, multiplied by the square root of the product of the electric resistivity into the magnetic permeability.

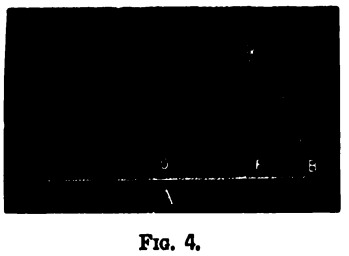

Fig. 4.

IV. Example of III: Let the conductor A be a thin flat bar, as shown in the diagram (Fig. 4), A′ being a tube surrounding A, or another flat bar like A, or a conductor of any form whatever, provided only that its shortest distance from A is a considerable multiple of the breadth of A. The thickness of A must be sufficiently great to satisfy the condition of II., and its breadth must be a large multiple of its thickness. (For copper carrying alternating currents of frequency 80 periods per second, these conditions will be practically fulfilled by a flat bar of 4cms. thickness and 30 or 40cms. breadth.) The current in it is chiefly confined to two strata extending to small distances inwards from its two sides. (For copper and frequency 80 periods per second, the time-maximum of intensity of the current at the surface will be about ϵ^2, or 7·4, times what it is at a distance 1·43cms. in from the surface.) The quantity of current per unit breadth, or, as we may call it for brevity, the surface-density of the current in each stratum, is determined by the well-known solution of the problem of finding the surface-electric-density of an electrified ellipsoid of conductive material undisturbed by any other electrified body. The case we have to consider is that of an ellipsoid, whose longest diameter is infinite, medium diameter the breadth of our flat conductor, and least diameter infinitely small. In this case the electric density varies inversely as $\sqrt{(O B^2 - O P^2)}$. The graphic construction in the drawing shows $P Q = \sqrt{(O B^2 - O P^2)}$, and we conclude that the time-maximum of the surface-density of the current varies inversely as P Q. The infinity, which in the electric problem we find for electric density of the ideal conductor, is obviated for the electric current problem by the proper consideration of the rectangular corners or the rounded edge (as the case may be) of our copper bar, which, though exceedingly interesting, is not included in the present communication. Suffice it to say that there will be no infinities, even if the corners be true mathematical angles.

V. Example of Cases I. and II.: Let A consist of three circular wires, C, L, and I, of copper, lead, and iron respectively. In Case I. the quantities of the whole current they will carry and the quantities of heat generated per unit of time in them will be inversely as their resistivities. In Case II., if the centres of the three circular cross-sections form an equilateral triangle, the quantities of heat generated in them will be directly as the square roots of the resistivities for C and L, and for I. would be as the square root of the product of the resistivity into the magnetic permeability, if the magnetic permeability were constant and the viscous or frictional resistance to change of magnetism nothing for the iron in the actual circumstances. This last supposition is probably true approximately with a permeability of $\frac{1}{80}$ for iron steel, according to Lord Rayleigh, if the current is so small that the greatest magnetising force acting on the iron is less than ·1 C.-G.-S.

VI. The dependence of the total quantity carried on extent of surface, according to the electrostatic problem described in II., justifies Snow Harris, and proves that those who condemned him out of Ohm's law were wrong, in respect to his advising tubes or broad plates for lightning conductors; but does not justify him in bringing them down in the interior of a ship (even through the powder magazine) instead of across the deck and down its sides, or from the masts

* "Collected Papers," Vol. III., Art. CII, § 35.

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along the rigging and down the sides to the water. The non-dependence of the total quantities of current on the material, whether iron or non-magnetic metals, seems quite in accordance with Dr. Oliver Lodge's experiments and doctrines regarding "alternative path" and lightning conductors. The case of alternate currents is, of course, not exactly that of lightning discharges; but from it, by Fourier's methods, we infer the main conclusions of II. and V., whether the discharges be oscillatory or non-oscillatory, provided only that it be as sudden as we have reason to believe lightning discharges are.

DISCUSSION.

Prof. HENRY A. ROWLAND, Ph.D., said that he had considered this question of parallel conductors himself, and he believed that he gave the theorem with regard to the distribution in the case of perfect conductors. In that case the distribution of current over the conductors was exactly the same as it would have been if they had been charged with electricity at rest. There was some theorem with regard to the capacity, &c.; but that was a special case of such a nature as to get away from the velocity of light. That was a much more limited problem than that given here; but it guided them with regard to the distribution of currents, because in the case of perfect conductors the distribution of current was exactly the same as the distribution of the density in the case of conductive breadth, so that it would make the conductivity a little less than that, and they were guided somewhat by that theory. But he did not know of any solution in the case where the conductors were not perfect. Sir William Thomson's conclusions were somewhat different to the case that he had mentioned.

Prof. OLIVER LODGE, F.R.S., said the experiments bore out the statement that more heat was developed in iron than in copper by the same alternate current passing through it.

ON ANTI-EFFECTIVE COPPER IN PARALLEL CONDUCTORS OR IN COILED CONDUCTORS FOR ALTERNATE CURRENTS.*

BY SIR WILLIAM THOMSON, F.R.S.

1. It is known that by making the conductors of a circuit too thick we do not get the advantage of the whole conductivity of the metal—copper, let us say—for alternate currents. When the conductor is too thick, we have in part of it comparatively ineffective copper present; but, so far as I know, it has generally been supposed that the thicker the conductor the greater will be its whole effective conductance, and that thickening it too much can never do worse than add comparatively ineffective copper to that which is most effective in conveying the current. It might, however, be expected that we could get a positive augmentation of the effective ohmic resistance, because we know that the presence of copper in the neighbourhood of a circuit carrying alternate currents causes a virtual increase of the apparent ohmic resistance of the circuit in virtue of the heat generated by the currents induced in it. May it not be that anti-effective influence such as is thus produced by copper not forming part of the circuit can be produced by copper actually in the circuit, if the conductor be too thick? Examining the question mathematically, I find that it must be answered in the affirmative, and that great augmentation of the effective ohmic resistance is actually produced if the conductor be too thick; especially in coils consisting of several layers of wire laid over one another in series around a cylindric or flat core, as in various forms of transformer.

2. Fig. 1 may be imagined to represent the secondary coil of a transformer consisting of solid square copper wire in three layers. For simplicity we suppose the axial length to be infinitely great, and straight; but the uniformity which this involves and a close practical application to its simplicity is realised in that excellent form of transformer which consists of a toroidal iron core completely covered by primary and secondary wires laid on toroidal surfaces. To simplify the mathematical work, I suppose the whole thickness of the three layers to be small in comparison with the greatest radius of curvature of the circular or flat cylindric surface on which the wire is wound, but if it is not so the solution is easily obtained, for the case of circular cylinders, in terms of the Fourier-Bessel functions. It is of no consequence for our present question what there be inside of coil No. 3, and, if we please, we may imagine there to be nothing but air; the drawing, however, indicates an iron core and space which might be occupied by the primary coil, if a transformer is the subject; or our coil A A A A may be the primary coil of a transformer with secondary coil and core inside it, and the alternate current maintained in it by an external electro-motive agent acting in an arc between its ends outside. Our present results are applicable to all these varieties of cases indifferently, all that is essential being that the total quantity of current be given at each instant, and be uniform throughout the whole length of the coiled conductor.

3. This last condition is secured by perfectness of insulation between all contiguous turns of the coil, unless we were considering so enormously long a coil that the quantity of electricity required for the essential changes of static electrification would be sensible as constituting drafts from, or contributions to, the current in the coil. The consideration of static electrification, involved in the maintenance of alternate currents through a coil such as that represented in Fig. 1, is exceedingly curious and interesting; but we do not enter on it at present at all, as in all practical cases the quantities concerned are quite infinitesimal in comparison with the whole quantity flowing in one direction or the other in the half period.

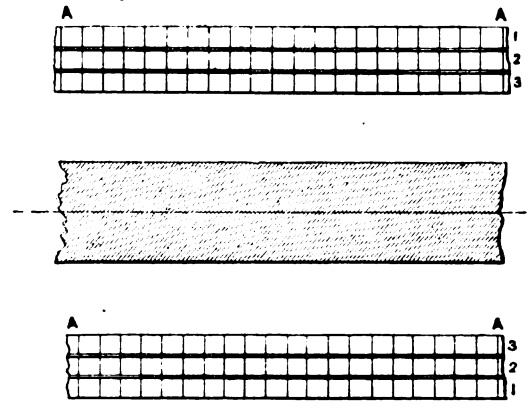

FIG. 1

4. In the drawing, the section of the wires is represented as square; but this is not essential, and in practice a flat rectangular ribbon would, no doubt for some dimensions of coils, be preferable. I assume the thickness of the insulation between the successive squares or rectangles in each layer to be infinitely small in comparison with the breadth of the rectangle; but the thickness of the insulation between successive layers, which is a matter of indifference to my calculations, may be anything; and would, in practice, naturally be, as shown in the diagram, considerably greater than the thickness of the insulation between the contiguous portions of the coil in each layer.

5. The full mathematical work, which I hope to communicate to the *Philosophical Magazine* for publication in an early number, includes an investigation of the self-induction of the coil with or without anything in its interior (such as core or primary wire of a transformer); but at present I merely give results, so far as effective ohmic resistance, or generation of heat in the interior of the wire of the coil A A A A itself, is concerned, which, as said above, is independent of everything in the interior, and of the mode in which the alternating current is produced, provided only that the total amount of electricity crossing the section of the wire per unit of time be given at each instant.

6. As a preliminary to facilitate the expression of these results, it is convenient first to give a general statement of the solution of the problem of laminar diffusion of a simple harmonic variation, applied to the case of electric currents in a homogeneous conductor. Let the periodically varying magnetic

* Paper read before the British Association in Section A, Leeds, September, 1890.

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force in the air or other insulating material in the neighbourhood of so small a portion, S, of the surface of a conductor that we may regard it as plane, be given. Resolve this magnetic force into two components; one, perpendicular to S, which we may neglect, as it has no influence in connection with the currents we are to consider; the other, parallel to S, which we shall call the effective component and denote by Y. Through any point O, of S, draw three rectangular lines O X, O Y, O Z, of which O Y and O Z are in S, and O X is parallel to the direction of the effective magnetic force component Y. Let now the value of Y at time t be

$$Y = N + M \cos \frac{2\pi t}{T},$$

where N and M denote constants, and T the period of the alternation. The varying magnetic force Y, to whatever cause it may be due, gives rise to currents parallel to O Z in the conductor, expressed by the following formula for γ, the current intensity at distance X from the plane S, provided T be small enough to fulfil the condition stated below:—

$$\gamma = \frac{M}{\lambda\sqrt{2}} \epsilon^{-\frac{2\pi x}{\lambda}} \cdot \cos\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} + \frac{1}{4}\pi\right);$$

where λ denotes what we may call the wave-length of the disturbance, and is given in terms of T, the period of the disturbance, and ρ and Π the resistivity and magnetic permeability of the substance, by the following formula:—

$$\lambda = \sqrt{\frac{T\rho}{\Pi}}.$$

For copper we have $\Pi = 1$, and $\rho = 1611$ square centimetres per second; and thus for 80 periods per second $\lambda = 4{\cdot}49$, or, say, $4\frac{1}{2}$ centimetres. In order that the formula for γ may be approximately true it is necessary, in the first place, that λ be small in comparison with the distance we must travel in any direction in the surface of S before finding any deviation of it from the tangent plane through O comparable with λ. Secondly, for a very good approximation, λ should be so small that we may be able to travel inwards in any direction from O, through a space equal to at least twice λ, without coming to any other part of the bounding surface of the conductor. If, for example, the surface be a flat plate, this condition requires that the thickness be more than twice λ. But (because $\epsilon^{-\pi}$ is less than $\frac{1}{23}$) the formula gives a very fair approximation, requiring for a half the thickness of the plate inwards from S no greater correction than about 4 per cent., even if the thickness of our plate be no greater than λ. When the thickness of the plate is less than 2 λ, we may consider waves of electric current as travelling inwards from its two sides, and being both sensible at the middle of the plate; and a complete solution of the problem is readily found by the method of images. But a direct analytical investigation, by which the proper conditions of relation to varying magnetic force on the two sides of the plate are fulfilled is the most convenient way of fully solving the problem, and it is thus that the results given below have been obtained.

7. The smallness of the insulating space between the successive turns in each layer of our coil A A A A, and the equality of the whole current through them all, prevent any surface disturbance from being produced at the contiguous faces, and allow the problem to be treated as if, instead of a row of squares or rectangles, we had a continuous plate forming each stratum. The smallness of the thickness of this plate in comparison with the radius of the cylindric surface to which it is bent, allows, as said above, the mathematical treatment for an infinite plate bounded by two parallel planes to be used without practical error. I have thus found an expression for the intensity of the current at any point in the metal of any one of the layers of a coil of one, two, three or more layers; and have deduced from it an expression for the quantity of heat generated per unit of time, at any instant, per unit breadth in any one of the layers. I need not at present quote the former expression; the latter is as follows:—With q to denote the dynamical value of the time-average of the heat generated per unit of time at different instants of the period, per unit breadth and unit length in layer No. i, from the outside of the coil, c^2 the time-average of the square of the total current per unit breadth, and a the thickness of the layer,

$$q = \frac{2\pi\rho}{\lambda} \Theta c^2,$$

where $$\Theta = \frac{\epsilon^{2\theta} + 2\sin 2\theta - \epsilon^{-2\theta}}{\epsilon^{2\theta} - 2\cos 2\theta + \epsilon^{-2\theta}} + 2i(i-1)\frac{\epsilon^{\theta} - 2\sin\theta - \epsilon^{-\theta}}{\epsilon^{\theta} + 2\cos\theta + \epsilon^{-\theta}},$$

and $$\theta = \frac{2\pi a}{\lambda}.$$

8. The numerical results shown in the table have been calculated, and the accompanying graphic representation (Fig. 2) drawn for me, by Mr. Magnus Maclean.

Table of Values of Θ.

$\frac{16\theta}{\pi}$	$i=1$	$i=2$	$i=3$	$i=4$
1	5·113	5·118	5·127	5·141
2	2·553	2·592	2·669	2·786
4	1·316	1·634	2·270	3·224
6	·9854	1·997	4·019	7·053
8	·9173	2·993	7·143	13·37
10	·9452	4·062	10·30	19·65
12	·9822	4·899	12·73	24·48
14	1·000	5·276	13·83	26·66
16	1·002	5·362	14·08	27·16
∞		5·000	13·00	25·00

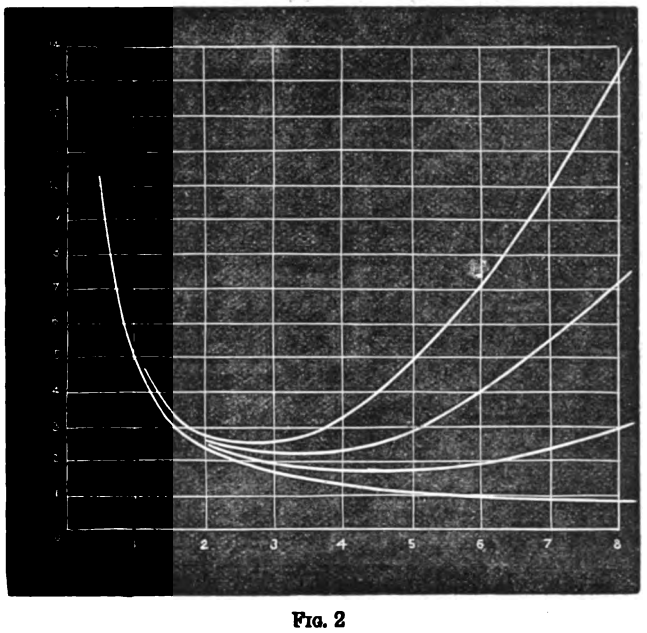

FIG. 2

8. We see from the table and curves that each curve has a minimum distance from the line of abscissas, and that each comes to a horizontal asymptote, parallel to the line of abscissas, for $\theta = \infty$. By looking at the formula we see that there is, in fact, an infinite succession of minimums and maximums in the expression for Θ; but it is only the first minimum and following maximum that occur within the range of variation of Θ, which we regard as sensible. In the case of $i = 1$ the formula gives $\theta = \frac{1}{2}\pi$ for the first minimum. The curves show for the cases of $i = 2, 3, 4$, respectively the first minimum at $\frac{16\theta}{\pi} = 4\frac{1}{2}$, $3\frac{1}{2}$, and 2·6, respectively. The thickness which corresponds to $\theta = \pi$ is the half wave length of the electric disturbance, which, as we have seen, is for copper 2·244 centimetres when the frequency of the alternations is 80 periods per second; and for this case, therefore, the thicknesses that give minimum generation of heat in the first, second, third, and fourth layers are respectively 11·22, 6·31, 4·91, and 3·65 millimetres. Anything more of continuous copper than these thicknesses in any of the layers would be not merely ineffective

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or comparatively ineffective, but would be positively anti-effective. Even with so small a thickness as 2·8 millimetres, for copper and frequency 80, line 2 of the table (corresponding to a sixteenth of the wave length) shows, in the first, second, third, and fourth layers, losses of 0·3 per cent., 2 per cent., 5 per cent., and 10 per cent. in excess of that due to the true ohmic resistance of the copper were it all effective. When the size chosen for the transformer and the amount of output required of it are such that a thickness of 2½ millimetres in the direction perpendicular to the layers is insufficient, a remedy is to be had by using braided wire, or twisted strand, with slight insulation of varnish or whitewash, crushed or rolled into rectangular or square form of the desired thickness and breadth. A very slight resistance between the different wires thus crushed together would suffice to cause the current to run nearly enough full bore to do away with any sensible loss from the cause which forms the subject of this communication.

ON AN ILLUSTRATION OF CONTACT ELECTRICITY PRESENTED BY THE MULTICELLULAR ELECTROMETER.*

BY SIR W. THOMSON, F.R.S.

The contact electricity of dry metals had been formerly discussed at great length; but the action was now admitted. The presence of brass and aluminium in an electrostatic instrument brings out a feature of contact electricity in the multicellular electrometer, which (see *The Electrician*, November 8, 1889, p. 6), consists of a number of cells and a number of needles, the needles attached to a stem which was suspended by a fine platino-iridium wire. If both cells and needles had been made of brass, or if both had been of polished aluminium, the difference due to contact electricity would not have been present.

Any difference between the substances will give the difference in question. When a difference of potential of 100 volts was maintained, the needles being +, and the cells −, the reading was 100·2. With the needles −, and the cells +, the reading was 99·8. No effect of this kind was visible in the early instruments; or at all events it was hardly visible, and never amounted to more than $\frac{1}{10}$ of a volt. Mr. Rennie, of the Board of Trade Standardising Laboratory, had found in a new instrument a difference of a quarter of a volt. That might be expected; the original instruments were not made up of polished metal parts, but of bits which were frequently handled and lay about in the laboratory; the condition of the surfaces was not, therefore, such as would give the results; but in well-polished instruments it was very noticeable. He had that morning received a letter from Mr. Rennie, who had made observations nearly every day for a month, and had found an error of ± ·5 to ·6 volt, halving that gave an effect of ·25 to ·3. There appeared to be a decrease in the error, probably due to the polish toning down.

DISCUSSION.

Prof. FITZGERALD said that he had given a warning in the Proceedings of the Royal Society of Dublin that errors from this cause might arise with instruments in which different materials were used. He alluded particularly to the effect produced with a guard-ring electrometer, in which the guard-ring was made of brass, and the disc was made of aluminium. The contact electricity would in this case give rise to a disturbing force which would introduce errors in delicate experiments. In instruments of this character care should be taken to use similar metals in the construction of those parts which could produce error. It was essential in guard-ring instruments that the discs should be of similar metal to the attracted disc.

Dr. FLEMING said that in the multicellular voltmeter which he possessed there was a slight difference in the readings of the voltmeter, according as the needle was positive or negative. Supposing 100 volts were put upon the instrument, then, if the needle were positive, the reading would be slightly greater than 100 volts; if negative, perhaps slightly less. He had been experimenting with a kind of unicellular electrostatic voltmeter. One side of the contact was made very rough, and the other was made very smooth. His experiments, so far as they had gone at present, seemed to indicate a very curious effect, namely, that the attraction between two surfaces, one of which was very rough and the other smooth, and which were kept at a certain definite constant difference of potential, would differ according as the surfaces were positively or negatively electrified; and that a considerable difference in the roughness of the two surfaces might make a very slight difference in the attraction between the surfaces when they were kept at a constant difference of potential. He had not fully completed his experiments.

Sir WM. THOMSON, in reply to Dr. Fleming, said that what he himself called the contact difference between the two surfaces had been anticipated in the very beginning of the trials of the instrument he exhibited, and some experiments were made showing that the contact difference of metals does tell upon the force of attraction between a movable piece of metal and a fixed piece of metal under electrification. The question put by Dr. Fleming had been the subject of a communication to Section A. In the case of aluminium and brass he should expect to find a sensible amount of difference between the reading with the connections one way, and the reading with the connections reversed, because of the contact difference between the two metals. The whole of the experiments in contact electricity with two surfaces of the same metal show a contact difference according to the degree of oxidation; for instance, bright copper opposed to copper oxidised by heat differed as much as a quarter of a volt. There was a slight correction to be made according as the needle and the casing of the instrument was positive or the other way. A difference of ·2 or ·25 volt had to be subtracted from the reading in the one case, or added to it in the other; but that was not a correction which gave any trouble in practice, because they knew it was in the instrument, and it would no doubt be exceedingly constant in the instrument. It was just possible, however, that it might gradually diminish in consequence of the very slow tarnishing of the two surfaces. The differences between rough surfaces and smooth surfaces were very interesting, and were most probably due to the difference of oxidation of the different parts of the rough surface.

* Abstract of Paper read before the British Association, in Section A, Leeds, September, 1890.

CONTRIBUTIONS TO THE MOLECULAR THEORY OF INDUCED MAGNETISM.*

BY J. A. EWING, F.R.S.

As the facts of induced magnetism become better known, increasing interest attaches to molecular theories, and increasing difficulty attends the theories that are current. Weber's fundamental conception that the molecules of iron or nickel, or cobalt, are always magnets, and that the process of magnetising consists in turning them from many directions towards one direction, has been strongly confirmed by the now well-established fact that there is a true saturation value, a finite limit to the intensity of magnetism, which may be reached or very closely approached by using a strong magnetic force †. Without going further back, to inquire (with Ampère) how the molecules come to be magnets, we may take this conception as the natural starting-point of a theory. But when we go on to examine the conditions of constraint on the part of the rotatable molecules which have been suggested to make the theory square with what is known about permeability, about residual magnetism, and other effects of magnetic hysteresis, about the effects of stress, of temperature, of mechanical vibration and so forth, we find a mass of arbitrary assumptions which still leave the subject bristling with difficulties. Many of the phenomena suggest, for instance, the idea that there is a quasi-frictional resistance which opposes the turning of the molecular magnets; this notion lends itself well to account for the most obvious effects of magnetic hysteresis and the reduction of hysteresis by vibration. On the other hand, it conflicts with the fact that even the feeblest magnetic force induces some magnetism. My object in this Paper is to refer to another (and not at all arbitrary) condition of constraint which not only suffices to explain all the phenomena of hysteresis without any notion of friction, but seems to have in it abundant capability to account for every complexity of magnetic quality.

In describing Weber's theory, Maxwell points out that, if each molecular magnet were perfectly free to turn, the slightest magnetic force would suffice to bring the molecules into complete parallelism, and thus to produce magnetic saturation. He continues:—"This, however, is not the case. The molecules do not turn with their axes parallel to the force, and

* Paper read before the Royal Society, June 19, 1890.

† Ewing and Low, *Phil. Trans.*, 1889, A, p. 221; *see* also H. E. J. G. du Bois, *Phil. Mag.*, April, 1890.

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this is either because each molecule is acted on by a force tending to preserve it in its original direction, or because an equivalent effect is produced by the mutual action of the entire system of molecules. Weber adopts the former of these suppositions as the simplest.* Weber supposes a directing force to act in the original direction of the molecules axis which continues to act as a restoring force in that direction after the molecule is disturbed. This assumed constraint is quite arbitrary; moreover, if it were the only constraint, there would be no residual magnetism when the deflecting force was withdrawn. Accordingly, Maxwell modifies Weber's theory by introducing the further assumption that when the angle of deflection exceeds a certain limit the molecule begins to take permanent set. The development of this, however, does not agree well with the facts. The alternative which is offered in the sentence I have quoted from Maxwell was not followed up by him, and seems to have been very generally overlooked, notwithstanding its obvious freedom from arbitrary assumption. Several writers, notably, Wiedemann† and Hughes‡, have recognised the inter-molecular magnetic forces by suggesting that the molecules, when unacted on by any magnetising force from outside, may form closed rings or chains, "so as to satisfy their mutual attraction by the shortest path."§ But Wiedemann expressly postulates a frictional resistance to rotation, which will prevent this arrangement from being more than approximately attained, and which may be more or less overcome by vibration ‖.

I lately commented on the fact that soft iron and other magnetic metals (notably nickel under particular conditions of strain¶) show a remarkably close approach to instability at certain stages in the magnetising or demagnetising process**. When the magnetic force reaches a particular value, the rate of change of magnetism with respect to change of force may become enormous. Referring to this in a Paper which has just been published ††, Mr. A. E. Kennelly has reverted to the idea of chains of magnetic molecules, held together by the inter-molecular magnetic forces, and contends that when such a chain is ruptured by applying a sufficiently strong external magnetic force it will fall to pieces throughout, and the molecular magnets which compose the chain will take their alignment suddenly. He accordingly sketches what he calls a "chain-theory" of magnetisation and an adaptation of the theory of Hughes, in which, however, he postulates an elastic resistance to the rotation of the molecules in addition to the constraint afforded by their mutual magnetic forces. Mr. Kennelly's remarks are highly interesting and suggestive; but I do not think (for reasons which will appear immediately) that the notion of closed magnetic chains can be maintained as a general account of the molecular structure of unmagnetised iron.

I have experimented on the subject by making a model molecular structure consisting of a large number of short steel bar-magnets, strongly magnetised, each pivot like a compass-needle upon a sharp vertical centre and balanced to swing horizontally. We cannot readily imitate in a model the two degrees of rotational freedom possessed by the axes of actual molecular magnets, but a group of magnets swinging in one plane gives a sufficiently good general idea of the nature of the equilibrium which is brought about by inter-molecular forces, and the manner in which that equilibrium is disturbed when an external force is applied. The model is very easily made. Each magnet is a piece of steel wire about 1-10th of an inch in diameter and 2in. long (Fig. 1) bent in the middle to bring the centre of gravity below the point of support. The hole, or rather recess, for the pivot is made by a centre punch: the pivot itself is a sewing-needle fixed upright in a small base-plate which is punched out of a sheet of lead. The bars swing with but little friction, and their pole-strength is sufficient to make the mutual forces quite mask the earth's directive force when they are set moderately near one another. The group is arranged on a board on which lines are drawn to facilitate regularity in grouping when that is wanted, and the board slips into a large frame or open-sided flat box wound round the top, bottom, and two sides, with a coil through which an adjustable current may be passed to expose the group to a nearly homogeneous external magnetic force. The coil is wound in a single very open layer, through which a sufficiently good view of the group inside is obtained. A liquid rheostat with a sliding terminal is used

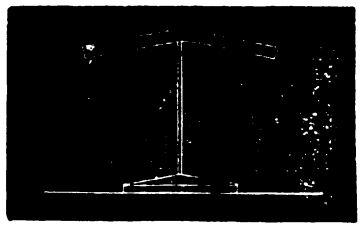

Fig. 1.

to secure continuity in varying the magnetic force. It is scarcely necessary to add that the magnetic force which is applied to the group is too weak to have any material effect on the magnetism of individual bars. It alters their alignment only, just as a magnetic force alters the alignment of Weber's molecular magnets.

When a number of these magnets are grouped either in a regular pattern or at random, and are left after disturbance to come to rest free from external magnetic force, they of course assume a form which has no resultant magnetic moment, provided the number be sufficiently great; but it is apparent that they do not arrange themselves in closed chains. Any such configuration would in general be unstable. Many stable configurations admit of being formed, and if the magnets are again disturbed and left to settle, the chances are much against any one configuration immediately repeating itself. One general characteristic of these configurations is that they contain *lines* consisting of two, three, or more magnets, each member of a line being strongly controlled by its next neighbours in that line, but little influenced by neighbours which lie off the line on either side. Thus, if there are two magnets simply, they form (as might be anticipated) a highly stable pair. With three magnets, two form a line along one side of the triangle joining the fixed centres, and the third lies parallel, or nearly so, facing oppositely. Four magnets will usually form two lines with directions which lie nearly along two sides of the quadrilateral; but diagonally opposite magnets may pair, leaving the others unattached. Suppose them set at the corners of a rectangle with unequal sides, they may lie in any of these forms (Fig. 1A),

Fig. 1A

if the inequality in distance be not too great. All these configurations are stable, and the condition of least energy, while making the first of them the most probable, does not prevent the occasional formation of the others. In a long line, the same condition leads in general to the formation of a continuous section; but it is by no means uncommon to find a line broken into two or more sections. Seven magnets grouped so that the centres of six form a regular hexagon, with one in the middle, have a great variety of possible stable configurations, of which these are examples (Fig. 2).

Experimental study of the forms which may be assumed by groups, and of the vibrations which may be transmitted through groups, is interesting, but to pursue it would be beside my present purpose. In all cases, the configuration assumed

* Maxwell, "Electricity and Magnetism," Vol. II., §443.
† Wiedemann, *Galvanismus*, Second Edition, Vol. II. (1), p. 373.
‡ Hughes, Roy. Soc. *Proc.*, May 10, 1883.
§ Hughes, *loc. cit.*
‖ Wiedemann, Phil. Mag. July, 1886, p. 52; *Elektricität*, Vol. III. §§ 784-785.
¶ See a Paper by H. Nagaoka, *Journal* of the Science College of the University of Tokio, Vol. II. (1888) p. 304.
** *Journal* of the Institution of Electrical Engineers, No. 84 (1890), pp. 38-40.
†† *The Electrician*, June 7 and 13, 1890

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by a group is such that there is stability for small displacements, but different positions of the group may be stable in different degrees, and if members of the group be turned through a sufficiently great angle, they become unstable, and fall into a new position of stability, bringing about a partial reconstruction of the lines that characterise the group. Special interest attaches to square patterns, from the fact that iron and nickel (probably cobalt also) crystallise in the cubic system. In a square pattern of many members, we find, in general, lines running parallel with all sides of the square when the group settles without directive force after a disturbance.

Let the group, or collection of groups, be subjected to an external magnetic force, H, gradually increasing from zero. The first effect is to produce a *stable* deflexion of all members except those which lie exactly along or opposite to the direction of H. This results in giving a small resultant moment to the

Fig. 2.

group (assuming that there was none to begin with), which increases at a uniform or very nearly uniform rate as H increases. This corresponds to the first stage in the magnetisation of iron or other magnetic metal (*a*, Fig. 3). The initial susceptibility is a small finite quantity, and it is sensibly uniform for very small values of H.

Suppose that, without going beyond this stage, we remove H; the molecular magnets, not having been deflected beyond the limit of stability, simply return to their initial places, and there is no residual magnetism. This, again, agrees with the fact that no residual magnetism is produced by very feeble magnetising forces. Up to this point there has been no magnetic hysteresis. But let the value of H be increased until any part of the group becomes unstable, and hysteresis immediately comes into play. At the same time, there begins to be a marked augmentation of susceptibility—that is to say, a marked increase in the rate at which resultant moment is acquired. It is not difficult to arrange groups in which the state of instability is reached with one and the same value of H throughout

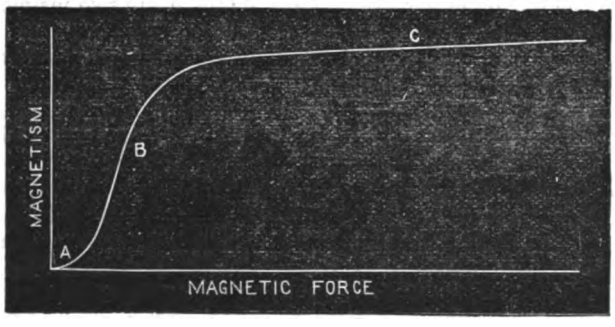

Fig. 3.

the group. But, in general, we shall have different elementary magnets, or different lines of them, reaching instability with different values of H. The range of H, however, which suffices to bring about instability throughout the whole, or nearly the whole, of the members in most groups is not large; we, therefore, find in the action of the model a close analogy to the second stage (*b*, Fig. 3) of the process of magnetisation, in which the magnetism rises more or less suddenly, as well as to the first stage (*a*).

During the second stage (*b*), the magnetic elements fall for the most part into lines which agree more or less exactly with the direction of H. If, at the end of this stage, we remove H, we find that a very large proportion of the moment which the group has acquired remains; in other words, there is a great deal of residual magnetism. To take an instance, suppose we have a group lying initially as in Fig. 4, and apply a magnetic force, H, in the direction sketched, the first stage (*a*) deflects all the molecular magnets slightly, without making any of them become unstable; the second stage (*b*) brings the molecules into the general direction shown in Fig. 5, or rather that is the direction they assume when H is removed, and the residual magnetism contributed by the group is then the sum of their moments resolved along H. When H is acting, the components along H are slightly greater, for the molecules are then (stably) deflected through a small angle towards the line of H.

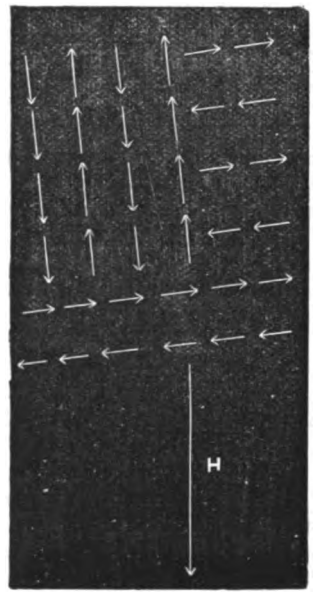

Fig. 4.

Let H be further increased—we now have the third stage (*c*, Fig. 3), which consists in the closer approach to saturation that is caused by the molecules being more nearly pulled into exact line with H (Fig. 6). Whether there will be instability during the deflexion of them from the lines of Fig. 5 will depend on the closeness of the pol s, and on the inclination of the lines of Fig. 5 to the direction of H (see below). In some groups saturation will be complete with a finite value

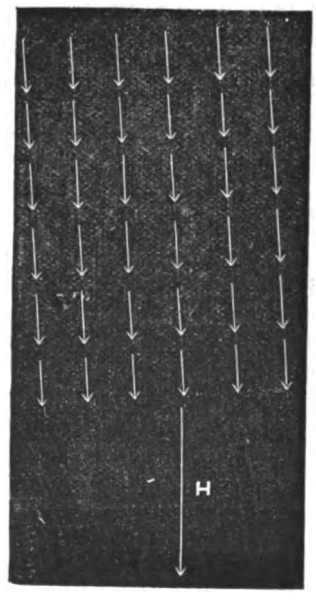

Fig. 5

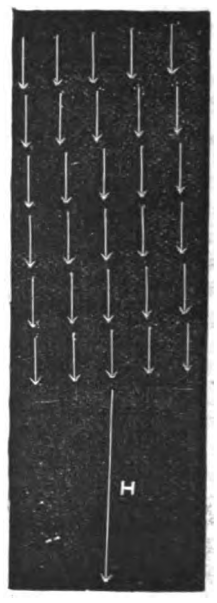

Fig. 6

of H; in others, it will only be closely approximated to. In magnetising any actual specimen of iron, we have, of course, to deal with a multitude of groups, the lines to which lie at very various inclinations to H. If we remove the force H at a point in stage *c*, we find very little, if any, more residual magnetism than was found at the end of stage *b*. The ratio of residual to induced magnetism is a maximum about the end

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of stage *b*, and diminishes as stage *c* proceeds. This, again, agrees completely with the observed facts.

There is *some* hysteresis during the removal (whether complete or partial) and reapplication of magnetic force, because (provided we have enough groups to deal with) there will be some lines of elements which pass to and fro through a condition of instability during the removal and reapplication of the force. For certain inclinations of the line, the movements are not reversible.

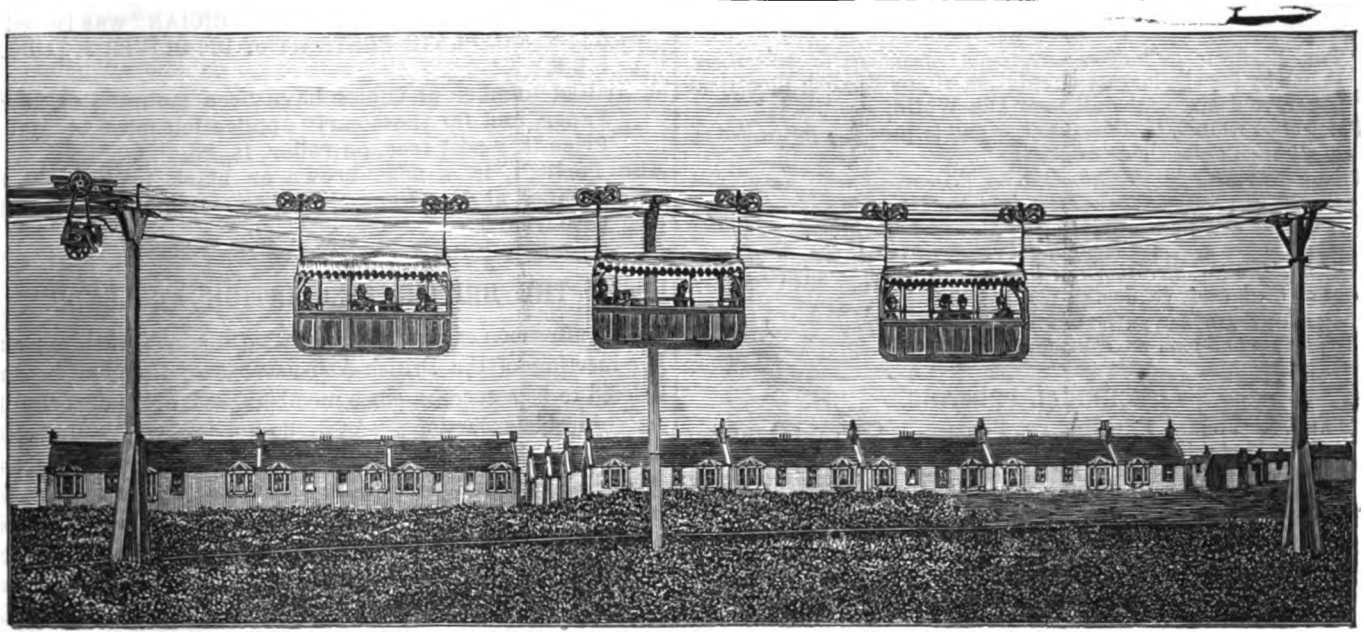
Suppose, next, that having applied and removed a strong force H, leaving strong residual polarity, we begin slowly to reverse H. At first the effects are slight; presently, however, instability begins, and as the force is increased within a narrow range, we find the molecules all upset. This is followed by a stage of nearly elastic deflexion as saturation is approached. Thus the well-known general characteristics of cyclic processes are all reproduced in the model (see Fig. 8).

Again, a small repeated cyclic change of H superposed upon a constant value of H produces small changes of aggregate polarity, which are reversible if the change of H is very small. This, as Lord Rayleigh has shown,* is what happens in a magnetic metal, and the susceptibility with respect to small cyclic changes is small in the model, just as it is in the actual solid.

(To be continued.)

THE TELPHER LINE AT THE EDINBURGH EXHIBITION.

The Telpher line put up at the Edinburgh Exhibition by the Electrical Engineering Corporation shows the most recent improvements, and is arranged so as to carry passengers as well as demonstrate the advantages of the system for this transport of goods.



The Telpher Line at the Edinburgh Exhibition.

The Edinburgh line consists of over a quarter mile of track, the flexible portion of it being constructed in spans of 50 ft. and the rigid ends in spans of 15 ft. The stand ropes on which the locomotive and carriages travel are of crucible steel and 1½in. in diameter. These are tightened, so that with a full load on the line there is a sag of about 2 ft. 4½ in. on the spans covered by the train. The arms supporting the stand rope are arranged so that they move in either direction, allowing the sag in the rope to follow the train as it moves along, thus not putting any undue strain upon the posts themselves. The stand rope at its junction with the rigid rail passes from a special descent junction saddle so arranged that the train rises from the rope on to the rigid rail without any jerk or other unsatisfactory movement. From the junction saddle the stand rope passes direct to a structure termed the abutment post; this is fastened to the substantial anchorages in the ground by flexible steel ropes 5in. in circumference. The strain upon the ends of the stand rope with a fully-load train is about five tons, and the strain upon the anchorages about eight tons. The current is conducted along a conductor which is not attached to the insulators on which it rests at any point, but merely rests upon them. From the locomotive a rigid arm projects underneath the conductor, but above the insulators, and slides along under the conductor, lifting it off the insulators as the arm passes them, allowing it to rest on them again after it has passed. This method of collection is recommended in the proposed "Waller-Man-ville" system of electrical traction, described in *The Electrician* of May 9, 1890.

The train, as will be seen from the illustration, is a very practicable one; the cars, which with the plant and the rest of the equipment were made at the works of the Electrical Engineering Corporation at West Drayton, are built much in the fashion of railway carriages, each car having two compartments and holding four persons, and each compartment being entered from a door with a railway latch. The whole of the car is suspended by iron hangers from two bogie trucks, the bodies of which latter consist of mitis iron castings resting on the axles of the wheels at each end. The hanger does not depend directly from the body of the bogie truck, but rests upon two vertical springs contained in boxes on each side of the body.

The locomotive consists of what is termed by the Corporation a swinging tub, and the motor drives a small countershaft, to one end of which is attached an electrical governor to maintain a set speed; the other end of the countershaft has upon it a chain wheel, which drives directly upon a larger chain wheel contained on the upper frame. The motor is suspended from the upper frame by a hanger, so arranged as to allow the whole to swing, the swinging movement thus allowed not interfering with the motion of the chain, as it is a movement radially to the centre of the large chain-wheel on the upper frame. The upper frame contains, in addition to the large chain-wheel, two driving wheels with malleable cast-iron tyres to grip the rope, each attached to a chain-wheel driven from the shaft supporting the large central chain-wheel.

This new method of cheap transport has, it is needless to say, attracted considerable attention at the Edinburgh Exhibition; and, in view of the many instances where telpherage might be advantageously employed, the Electrical Engineering Corporation has shown great enterprise in bringing the system so prominently before the public.

* *Phil. Mag.*, Mar., 1887.

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OUR SUPPLEMENT.

With the last Number of "THE ELECTRICIAN" was issued a fine STEEL PLATE PORTRAIT of Dr. OLIVER J. LODGE, F.R.S.

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THE BRITISH ASSOCIATION AT LEEDS.

The afternoon of Saturday was very fine in Yorkshire; and the meeting of the British Association may therefore be considered to be a success, since members had every opportunity for enjoyable excursions. As we do not pretend to appreciate the Association in its present form, we shall not attempt to generalise pleasantly on the "advancement of science," for which it is supposed to be founded. We shall endeavour to avoi being cynical; but if remarks have to be made on the subject, they may as well be candid, especially as they are aimed at no individuals. The most remarkable feature about the annual meetings of the British Association is that although it is admittedly a gathering of a large proportion of the leading scientific men of the day, hardly any results, so far as the "advancement of science" is concerned, are to be found, except in the contents of the Papers which are brought by some of them to the Sections.

The Presidential Addresses too often afford examples of a deplorable waste of the time and energies of an able man. Addresses of this kind are, perhaps, a necessary evil, but they are occasionally atoned for by brilliant exceptions. They differ in no marked respect from the inaugural addresses of the presidents of the scientific societies. The Institution of Electrical Engineers has on more than one occasion found a leader who not only writes his best on his own subject, but invites discussion on his address. Prof. HUGHES and Dr.

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HOPKINSON are examples of such. They, by the way, are among those who are conspicuous by their absence from the meetings of the British Association. Sometimes a man like TYNDALL will set up a landmark in literature by a memorable essay, which is not marred by a list of poets, divines, and other ornaments of the past history of the locality, or by hearsay history of subjects which lie outside his own work. The address to Section A to which we have alluded in another column was of a modest but useful type. Those who write Papers for Societies know well how much they learn in getting up a subject, however familiar it may be to them; and when a man endeavours to give, not a sketch of his own subject, but an account of some phase of it, discussing its aspect from some particular standpoint, and indicating how it is related to some other branch of knowledge, he benefits both himself and his audience far more than if he attempted to expound or to popularise his own specialities. The addresses of Dr. GLAISHER and of Prof. MARSHALL were of this commendable type.

We have referred to the singular limitation of the results of the meeting to the contents of the Papers. As far as the holding of the meeting is concerned, the Papers might have been sent in to the Secretaries without going through the form of presentation to an audience, except in the rare cases where experiments are made. The results which one might expect from the gathering of so many able minds are those which should arise from debate and discussion upon the subjects presented to them. The length of the discussions, or the standing of the men who take part in them, at the sectional meetings of the British Association is no indication whatever of the importance of the communications. When the programme containing the list of Papers for the day is issued nominally at 8 a.m. on the morning on which they are to be read, but which is practically in the hands of those members who apply for them at, say, half-past nine or ten, those who speak have to do so on the spur of the moment, and their utterances are, as a rule, of far less value than at the meeting of the scientific societies. The length of the discussion is, therefore, not infrequently inversely as the scientific worth of the Paper. The valuable results of the discussions at meetings of the Institutions of the Civil and Electrical Engineers are mainly due to the custom of printing the papers and distributing them to members before the meetings. The effect of this is that the debates are often more important than the Papers themselves. It was evident on Friday last that if some of the members had been prepared for Prof. EWING'S remarkable magnetic theory, or rather for his explanation of the model which exhibits and combines several of the features of older hypotheses with new suggestions and developments, and if a reasonable discussion had thus been possible, the theory of magnetism might have made so marked a stride that the Leeds meeting of 1890 would have been a notable landmark in the history of the subject. As it was, several members had wearied of the atmosphere of the meeting house, or had been compelled to go out for lunch; others returned only in time for the latter part, and many had been fasting since the morning. These conditions, which are repeated at every meeting, are conducive neither to appreciation of the subject, prolonged discussion, or to physical comfort.

In short, by the British Association meetings as at present arranged, the minimum of scientific progress is effected by the maximum expenditure of energy. The meetings already fail to attract many leading men; and unless there is some change of method it is very probable that many of those who at present attend will grudge the sacrifice of a week of their holidays, and will leave the Association in the hands of a small well-meaning clique and a few advertisers and bores. The fact is not to be disguised that these meetings are holiday affairs, and that men who will submit to the regulations of scientific societies in their winter session do not care to treat matters quite so seriously at a summer gathering. Is it not time that these meetings should be managed so as to attain more satisfactory results? Why should not the Sectional Committees be of more manageable dimensions and their work more concentrated? Let the number of Papers to be read in each Section be rigorously limited, and printed well before the meeting. It is possible that a higher grade of Papers would then be contributed, their originality might possibly be more marked, and the discussions on them more to the point. Moreover, if some such arrangement were instituted there would be some *kudos* attached to the reading of a Paper before the British Association—a quality which is at present conspicuous by its absence. Formal debates on matters of general scientific interest should become a regular feature of the meetings. There can be no better opportunity for them than at these annual gatherings, where it might be expected that something of the old broad scientific spirit would be infused into the discussions by the presence of so many varieties of the scientific species. Reforms somewhat on these lines should be speedily undertaken, unless the British Association is to go the way of all institutions which fail to adapt themselves to the times.

THE BRITISH ASSOCIATION AT LEEDS.

RÉSUMÉ OF PROCEEDINGS.

WEDNESDAY, SEPT. 3.—Presidential Address of Sir Frederick Abel.

THURSDAY, SEPT. 4.—The meeting of Section A opened with an address by Dr. Glaisher on the relation of pure mathematics to physics. A report of the Committee on "Electro-optics" was brought up, but it was merely an intimation that no regular work had yet been done. Mr. Swinburne then read a Paper on the details of the construction and use of vacuum pumps; and Mr. Shenstone described some joints and taps for the same purpose. Profs. Barr and Stroud showed photographic apparatus very cleverly contrived to facilitate the making of lantern slides for educational and lecture work. M. du Bois described the measurement of the refractive index of various metals. Thin films of platinum, nickel, iron, and cobalt, were deposited on glass, and these films were thickened locally by electro-deposition. The thickening was painted with stripes of black paint, leaving bands showing the thickest and thinnest parts and a graded part. The latter was practically a wedge or prism of a very small angle, and this was used to determine the refractive index, the thickest part being thin enough to transmit light. Sir W. Thomson described the effect of using aluminium for the needles and brass for the cells of the multicellular voltmeter. (For description of this instrument, see *The Electrician*, November 8, 1889.) Different metals being used, the contact electricity was found to be sufficient to give rise to an error. The present instruments are (we are informed) being made with aluminium cells. Lord Rayleigh followed with some accounts of defective colour vision; and Mr. W. N. Shaw read a Paper on ventilation, a subject which he has recently studied with apparatus made on the apparently unlikely principle of the Wheatstone bridge. While this was being read, the report of the Committee "On the Silent Discharge of Electricity," was read in Section B. This merely stated that the work had not yet been begun. In Section G (Mechanical Science) a description was given of the Victoria Torpedo, of which we recently gave a short account. (See *The Electrician*, August 8, p. 370.)

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FRIDAY, SEPT. 5.—A discussion on Electrical Units was announced to be opened by a Paper by Mr. Glazebrook and another by Prof. J. Viviamu Jones. The former was important historically, and showed that the mean value of the best determination of the ohm was 106·3, this being the length in centimetre of a column of mercury one millimetre square, at 0 centigrade. Prof. V. Jones's Paper was interesting on account of its mechanical details; but the discussion was very disappointing, no general debate on electrical units being attempted. Sir W. Thomson read two Papers on the mutual action of alternate current in conductors; and Prof. Ewing contributed the most valuable and important communication of the meeting in describing his molecular theory of induced magnetism. Five other Papers were postponed.

SATURDAY, SEPT. 6.—Sir W. Thomson described a method of determining in absolute measure the susceptibility of diamagnetic or feebly magnetic bodies; and a report and discussion on electrolysis, together with Papers by Mr. Shaw and Prof. Ostwald, followed.

MONDAY, SEPT. 8.—Sir William Thomson described his meter, an instrument which is admittedly in an early stage, and the multi-cellular voltmeter (*The Electrician*, November 8, 1889); he also described an engine-room voltmeter (*The Electrician*, August 8, 1890), an ampere gauge, and a new form of volta-pile, useful in standardising work. Mr. Kapp read a Paper on the Lineff system of electric traction, which gave rise to little that was useful in the discussion. A Paper on the physiological effects of alternate and continuous currents, by Mr. Lawrence and Dr. Harries, was then read, the discussion turning to details of the electric execution. Mr. Wilson Hartnell attacked the fire insurance offices for undue severity in their rules; Mr. Barbour Starkey concluded with a Paper on his well-known system of addingcarbonate of soda, and on experiments with sawdust and plaster of Paris. In the discussion, it was pointed out that sulphate, not carbonate, should be used.

At the meeting of the general committee held in the Council Chamber at the Town Hall, the place for the 1892 meeting was selected, and officers appointed for next year's meeting at Cardiff. The Secretary read a communication from the Lord Provost of Edinburgh inviting the Association to hold its meeting in 1892 in that city. Sir William Thomson formally moved that the meeting of the Association in 1892 be held in Edinburgh. The motion was seconded by Prof. Fitzgerald, and on being submitted to the meeting was carried unanimously. Lord Rayleigh proposed that Dr. William Huggins should be appointed president of the Cardiff meeting. Dr. Glaisher seconded the resolution, which was adopted. After some discussion as to the most suitable time, it was decided that the Cardiff meeting should commence August 19th.

TUESDAY, SEPT. 9.—No less than 14 Papers were got through in Section A on this day. Prof. Mascart began with a discourse in French on the optical phenomena of coloured and achromatic fringes observed in minerals. Lord Rayleigh exhibited photographs of water jets taken by the light of a discharge of a Leyden jar. Mr. Glazebrook took a report on electrical standards, together with Papers on resistance coils; an air condenser of Dr. Muirhead's design; the specific resistance of copper; and a comparison of platinum with mercury thermometers. Mr. Preece described the great superiority of French over English steel for making permanent magnets, and discussed whether this was due to the material or to the tempering. Mr. O'Shea described the effects of oxidation of manganese steel in increasing its magnetic properties; and Mr. Swinburne followed with an account of magnetic tests of iron. He also read a brief note on the compensation of alternate current instruments. Prof. Fitzgerald read a short but abstruse Paper on theoretical stability with magnetic forces. Dr. Oliver Lodge read and commented on a Paper by Mr. Trowbridge on electrical oscillations, and another by himself on the electrostatic forces between conductors carrying currents.

WEDNESDAY, SEPT. 10.—Prof. Fitzgerald read a Paper on the "J." of Maxwell's equations in relation to Hertz's discoveries. Prof. Barrett presented the report of the Committee on "Molecular Phenomena attending the Magnetisation of Iron," and gave a *résumé* of the recent work of Hopkinson, Osmond, and others on recalescence of iron and steel, and their allotropic states. Prof. Fitzgerald discussed the thermodynamical aspect of the subject. A Paper by Mr. Swinburne on the resistance of the human body under direct and alternating pressures was taken as read. Mr. F. H. Varley exhibited and described a photometer; and after a brief description of some spectrum photographs by Mr. Gibbs, the meeting terminated.

The President of the Section, in closing the meeting, observed that he had attended nineteen meetings of the British Association, and at none of them had he heard so many valuable Papers, and such interesting discussions. Sir William Thomson said that the meeting could not separate without according their thanks to Dr. Glaisher for the sympathetic manner in which he had presided, although the subjects of the majority of the Papers lay outside the pure mathematics in which he had so distinguished himself.

At one o'clock the last meeting of the General Committee was held in the Council Chamber of the Town Hall. The chair was taken by Sir F. Abel. Mr. Vernon Harcourt (general secretary) reported the numbers of tickets sold at this meeting, which were as follows:—Old life members, 259; new life members, 21; old annual members, 368; new annual members, 92; associates, 680; ladies, 334; foreign members, 21—total, 1,775. The total receipts were £1,776. Among the grants recommended by the Committee of Recommendations were the following:—Professor Carey Foster—electrical standards, £100; Professor Fitzgerald—electrolysis, £5; Professor O. J. Lodge—discharge of electricity from points, £10.

THE MEETING OF THE BRITISH ASSOCIATION.

The following is a complete list of the electrical Papers read, reports presented, and instruments exhibited at the recent meeting of the British Association:—

SECTION A.

PROFS. BARR and W. STROUD.—"On the Use of the Lantern in Class-room Work."

PROF. J. A. EWING, F.R.S.—"On the Molecular Theory of Induced Magnetism."

PROF. G. F. FITZGERALD, F.R.S.—"On an Episode in the Life of J. (Hertz's Solution of Maxwell's Equations)."

PROF. G. F. FITZGERALD, F.R.S.—"On Kinetic Stability with Magnetic Forces."

R. T. GLAZEBROOK, F.R.S.—"On Recent Determinations of the Absolute Resistance of Mercury."

PROF. J. VIRIAMU JONES.—"On Suggestions towards a Determination of the Ohm."

PROF. O. LODGE, F.R.S.—"On Electrostatic Forces between Conductors carrying Currents."

PROF. E. MASCART.—"Sur les Perturbations Magnetiques en France."

L. T. O'SHEA.—"On the Effect of Oxidation on the Magnetic Properties of Manganese Steel."

PROF. W. OSTWALD.—"On the Action of Semipermeable Membranes in Electrolysis."

W. H. PREECE, F.R.S.—"On the Character of Steel used for Permanent Magnets."

A. W. RÜCKER, F.R.S., AND T. E. THORPE, F.R.S.—"On Regional Magnetic Disturbances in the United Kingdom."

W. N. SHAW.—"Report on the State of our Knowledge of Electrolysis and Electro-Chemistry."

W. A. SHENSTONE.—"Some new Vacuum Joints and Taps."

J. SWINBURNE.—"On the Resistance of the Human Body under Direct and Alternating Pressures."

J. SWINBURNE AND W. F. BOURNE.—"Testing Iron."

J. SWINBURNE.—"The Compensation of Alternate-Current Instruments."

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J. SWINBURNE.—"Notes on High Vacua."

SIR W. THOMSON, F.R.S.—"On an Illustration of Contact Electricity presented by the Multicellular Electrometer."

SIR W. THOMSON, F.R.S.—"On a Method of Determining in Absolute Measure the Magnetic Susceptibility of Diamagnetic and Feebly Magnetic Solids."

SIR W. THOMSON, F.R.S.—"On Alternate Currents in Parallel Conductors of Homogeneous or Heterogeneous Substances."

SIR W. THOMSON, F.R.S.—"On Anti-Effective Copper in Parallel or in Coiled Conductors for Alternate Currents."

F. T. TROUTON.—"Experiments to Determine Wave-Velocity in Dielectrics."

J. TROWBRIDGE.—"On Electrical Oscillations."

F. H. VARLEY.—"On a new Direct-reading Photometer."

Report of the Committee on Electrical Standards, with the four following Papers:—

T. C. FITZPATRICK.—"On the Specific Resistance of Copper."

R. T. GLAZEBROOK, F.R.S.—"On Variations in some Standard Resistance Coils."

R. T. GLAZEBROOK, F.R.S., AND A. MUIRHEAD.—"On some Standard Air Condensers."

E. H. GRIFFITHS.—"A Comparison of a Platinum Thermometer with some Mercury Thermometers."

Report of the Committee on Molecular Phenomena attending the Magnetisation of Iron.

Report of the Committee on Electro-Optics.

Report of the Committee on Electrolysis.

SECTION B.

Report of the Committee on the Silent Discharge of Electricity.

SECTION G.

W. J. S. BARBOUR-STARKEY.—Secondary Batteries.

WILSON HARTNELL.—"Electric Lighting and Fire Insurance Rules."

F. HIGGINS.—The Column Printing Telegraph.

GISBERT KAPP.—"The Lineff System of Electric Traction."

H. N. LAWRENCE and DR. HARRIES.—"Alternato *v.* Continuous Currents in relation to the Human Body."

G. R. MURPHY.—The Victoria Torpedo.

W. H. PREECE.—"On the Form of Submarine Cables for Long-Distance Telephony."

SIR W. THOMSON, F.R.S.—"On a New Electric Meter. The Multicellular Voltmeter. An Engine-Room Voltmeter. An Ampere Gauge. A new form of Voltapile, useful in Standardising Operations."

THE LINEFF ELECTRIC TRAMWAY.*

BY GISBERT KAPP, M.I.E.E.

Engineers and tramway managers, not less than the travelling public, are agreed as to the desirability of replacing animal by some sort of mechanical traction; and electrical engineers in particular are convinced that of all methods of applying mechanical power that involving the use of electromotors is the most convenient for the ordinary type of tramline. On lines with exceptionally steep gradients the cable has the advantage over the steam locomotive and electromotor that the weight of the car to be hauled up the grade is a minimum; but on lines which are not too steep to be worked by steam or horses this advantage is on long lines more than counter-balanced by the waste of power involved in keeping the cable itself in motion; and it is in these cases which form the majority that the electromotor has the most promising field of application. It may be asked how it comes that with all these circumstances in its favour, electric traction on tramways has made in this country so little progress. We have cheap coal, good steam-engines, excellent dynamos, and thoroughly reliable and efficient electromotors. The transmission of power from the motor spindle to the axle of the car, although not so easy a problem as it might perhaps appear at first sight, does not present any insuperable difficulties, and has, in fact, been very satisfactorily solved by more than one engineer. The application of electricity to traction should therefore be an easy matter. Yet progress is slow. The explanation appears to be that although the generation of the electric current taken by itself is easy enough, and the conversion of this current into mechanical power taken by itself is easy enough, the connecting link between the two processes, namely, the conveyance of the current from the dynamo at the tramway depôt to the car on the line, is a matter of some difficulty, and as yet we have no system of conveyance which may be considered as satisfactory in every respect. It is in this direction that inventors should work. There is very little need for improved dynamos, motors, switches, or other gear; all these appliances, though not absolutely perfect, are quite good enough for practical work. There is, however, great need for improved methods of conveying the electric current to the car in a manner which shall at once be economical, certain, free from danger to persons and animals, offer no obstruction to the general traffic in the streets, and be acceptable on æsthetic grounds. All these conditions except the first are fulfilled in those systems where a storage battery is used for conveying the current from the dynamo at the depôt to the motor on the car; but unfortunately the first condition is too important to be neglected, since the fundamental reason for substituting mechanical for horse traction is not a humanitarian or scientific one, but the aim to save a penny or two per car mile, and thus increase the financial prosperity of the company. I do not say that such a saving may not be effected by the use of battery cars; but I say that up to the present we have no practical proof that such cars are more economical to work than horse cars; and I maintain that whatever saving may result from the adoption of batteries, a greater saving under the same circumstances must result from direct working; that is, working under some system of conveying the current direct from the dynamo to the motor by means of a conductor. On the other hand, there may be reasons for preferring the storage car, notwithstanding its lower efficiency; but I do not propose to enter into this subject, as it can only be satisfactorily discussed with reference to the local conditions in each particular case. My object is to bring before you a new system of direct supply for tram-cars, which has recently come under my notice, and which seems to fulfil all the conditions stated above.

When we have to convey current to the car by means of a conductor, this conductor must run along the line either above or below ground. In the former case it may be a wire suspended along poles, or a rail resting on insulating supports close to the ground, or it may be formed by the tram-rails themselves. All these arrangements have been tried, but it is needless to say that they are inadmissible for urban and suburban lines in this country. With such lines the first condition must necessarily be to place the conductor underground. As usually carried out this system involves the adoption of a slot in the road through which passes a slipper or contact-shoe attached to the car, and which establishes electrical connection between the conductor underground and the motor on the car. The system is, as experience shows, practically workable; though the slot, which must admit dirt and moisture into the underground channel and may to a certain extent inconvenience other traffic, is a disadvantage. This disadvantage may perhaps not be very great considered from a purely technical point of view, but such as it is it has to be taken into account. If we consider the question from the point of view which will naturally be taken by the local authorities and the public whom they represent, we shall come to the conclusion that the slot is a great disadvantage to the general traffic, and that its abolition is highly desirable. How to abolish the slot and yet retain electrical connection between the underground conductor and the motor on the car is the problem which has been solved in the system of electric tramway I am about to describe.

The conductor consists of bare copper strip or cable, and of iron strip. The latter is galvanised so as to protect it from rusting. It lies on the copper conductor, and both are enclosed in a sealed channel formed of asphalte. The copper conductor rests upon the bottom of a trough made of a succession of glazed tiles, and the cover to this trough is formed by the lower flanges of iron rails arranged in short sections so as to be insulated from each other. The head of one rail reaches up to the surface of the road; the head of the other is cut off, and this rail is, therefore, completely buried in the asphalte. The surface rail, which may be arranged alongside one of the ordinary tram rails, or in the centre of the track, is in electric and magnetic contact with an electromagnet carried under the car. This magnet runs upon the surface rail on wheels, which form its north and south poles. The distance of the wheels is greater than the length of a section of insulated rail, so that successive sections become oppositely magnetised. This causes the iron strip immediately below the magnetised region to be attracted upwards and thus come into contact for a length of several feet with the under side of the two sectional rails. At the same time the iron strip to both sides of this region remains in contact with the copper conductor, and forms thus an electrical connecting link between the copper conductor and a few sections of insulated rail under the car. The current passes from the surface rail through the body of the electro-magnet (which is insulated from the body of

* Paper read before the British Association in Section G, Leeds, September, 1890.

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the car) into the motor, and finally into the ordinary tram rails and earth in the usual manner. The electro magnet is energised by a shunt current obtained from the main conductor, but to provide for the possibility of dropping the strip from some unforeseen cause there is placed on the electro-magnet a third thick wire coil, which can at all times be energised by two storage cells carried on the car, and thus the strip can be picked up and the main circuit again established if it should have been accidentally interrupted. I may, however, at once state that during some tests which I made on an experimental line of this kind, and which lasted over several days, there has been no need for the picking-up battery, as the current was never lost. I shall say a few words about the results of these tests presently; but before entering upon the practical results I would draw your attention to a question of both practical and theoretical importance—namely, the way in which Mr. Lineff makes use of magnetic lines of force to effect the attraction of the iron strip. It might, perhaps, be thought that the most direct and therefore the best way of utilising the lines of force would be by one single line of sectional rail through which there would be longitudinal magnetic flux corresponding with the fore and aft position of the poles and attraction of the strip at every gap between two sections. Experiment has, however, shown that this apparently direct way is by no means the best way, and that far more satisfactory results can be obtained by arranging a more roundabout course for the lines of force. This is attained by the employment of the subsidiary or buried rail, the gaps in which do not exactly correspond with those in the main or surface rail, but are shifted forward by a certain amount. In consequence of this arrangement, the buried rail acts as a kind of magnetic bridge (*see* Fig. 1) to successive portions of the surface

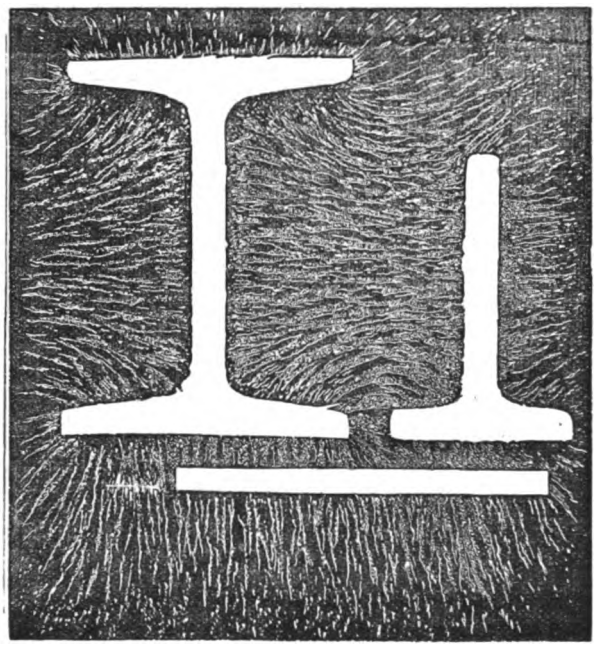

Fig. 1.—Lineff System Magnetic Circuit.

rail, and this action takes place in two ways, one direct and the other indirect. The direct way is longitudinal, and does not affect the strip at all. The indirect way is both longitudinal and transverse, the latter passing several times through the strip. The buried rail is a rather imperfect bridge to the lines of force traversing it longitudinally, because its magnetic resistance in that direction is great, but this rail forms a very efficient bridge for lines passing through it transversely, owing to its lower magnetic resistance in that direction, which includes the strip. This flow of magnetic force transversely is, therefore, that which effects the attraction of the strip, and may be represented as a series of magnetic stitches passing to and fro between the two sets of rails and the strip.

This action will be understood by reference to the diagrams 2 to 4, which represent the magnetic condition of the rails for three positions of the electro-magnet. A represents the surface rail, and B the buried rail. The energy provided to attract the strip is only 180 watts, or equivalent to that consumed by three glow lamps; and this I have found sufficient under all circumstances. Fig. 6 is a cross-section, Fig. 5 a plan, and Fig. 7 a longitudinal section of the line and electro-magnet.

The experiments to which I have referred were undertaken to see whether the whole system is practically workable. The first question which presented itself was whether the wave in the strip running along at the speed of the car was likely to induce subsidiary waves either in front or behind the car, whereby exposed sections of the surface rail might become charged and be a danger to ordinary traffic. To investigate this matter a pilot brush was fitted to the car at different distances from its centre, and connected with an electric bell. The pilot brush was so placed as to slide over the surface rail, and if on a charged section the bell would sound. It was found that the charged region was at all speeds considerably shorter than the length of an ordinary car. Contact tests were also made over the whole line at greater distances from the car than the pilot brush could reach, and in no case have I found an exposed section of rail charged. There was, further, the danger that with a dry and dirty line the collection of current might be accompanied by sparking, which would frighten horses; but this difficulty was overcome by fitting wire brushes to the pole-shoes of the electro-magnet.

An important point in all conductor systems of electric tramway is the energy spent in collecting the current. With the overhead wire system this is very small and practically inappreciable. With an underground system it is naturally larger. In the first system elaborated by Mr. Lineff, the flexible underground shoe with its trailing rope required from 20 to 48lb. for its propulsion. In the series system the "arrow" rubbing through the "spring jacks" must necessarily also require the application of considerable force; but I have no figures on this point. In the new Lineff system the electro-magnet rolls on the surface rail, and the propelling energy is consequently small. I am informed by Mr. Lineff that he has succeeded in reducing it to 210 watts with the magnet energised. The whole power spent in collection of current is therefore about half a horse power.

The insulation resistance of the conductor was tested both by the bridge method (48 Leclanché cells, Post Office pattern bridge, and mirror galvanometer), and by passing the leakage current through a voltmeter, and the two methods gave fairly accordant results. The highest reading I recorded by the voltmeter test, when the full pressure of 230 volts was on the conductor, was 5,400 ohms, and the lowest 3,550 ohms. From these figures it appears that the average insulation is 186 ohms per mile.

To ascertain the surface leakage I also applied the voltmeter test, and found the following insulation resistances of three charged sections of magnetic rail. With the line clear and moist, 4,183 ohms; with the line very wet and covered with mud and horse droppings, 980 ohms. Taking 2,000 ohms as an average, the loss of power at 300 volts by surface leakage per car amounts to 45 watts.

The mechanical strength of the line was tested by running a steam roller over it in various directions, under which treatment the line suffered no damage whatever.

DISCUSSION.

Major-General WEBBER said the Lineff system met in a remarkable way and to a very large extent a want which they had all been feeling for some time, that is to say, some means of connecting the motor which actuates the car with an underground conductor. In the absence of information as to the voltage or the pressure which actuated the motor, he failed to see that they did securely prevent the strip remaining in contact after the passage of the car. He also felt some doubt as to the insulation of the conductor shown in the diagram on the blackboard.

Mr. W. H. PREECE said that under Mr. Kapp's guidance he had inspected the working of the Lineff system near Chiswick, and could corroborate every word in the Paper. His fears for the practical success of the system were principally that there might be a failure of the contact between the flexible strip and the rail, but that was virtually got over by having a very broad strip and long length in contact, and also by the fact that the flexible iron conductor was galvanised and therefore always clean; moreover, the galvanisation on the surface had precisely the same effect as the insertion of pieces of paper on the pull-pieces of electro-magnets, that is, that as the energising power ceases the armature drops off; so here as soon as the current ceases the flexible strip will fall to the bottom of the trough. There was no doubt that of all the systems yet produced, this one had the air of practicability about it; but it would be quite impossible to give a definite opinion upon it until it has received the test of actual practice.

Prof. EWING referred to the correspondence between the Lineff system and the system originally introduced by Profs. Ayrton and Perry, of having a thoroughly well-insulated conductor underground, which was to be connected when the car passed with successive sections of a not so well insulated conductor serving as a surface conductor. This was done by Mr. Lineff in a very much more satisfactory way than by the mechanical methods of connection proposed by Profs. Ayrton and Perry.

Major-General WEBBER said they might dismiss the question of insulated returns from their minds. He had reason to believe that before very long almost all the telephone systems in the country would be served by metallic returns and not by earth returns; and in such a case it would not be necessary for the telephone companies to insist upon such clauses.

Mr. KAPP, in reply, said that with regard to the telephone question, the three-wire system offered a very simple way of greatly minimising the disturbance. He did not believe the telephone would suffer very much from the comparatively low currents of tram lines. The strip did *not* remain in contact. His own fear had been that there would be enough residual magnetism to keep the strip up · and another fear had been that

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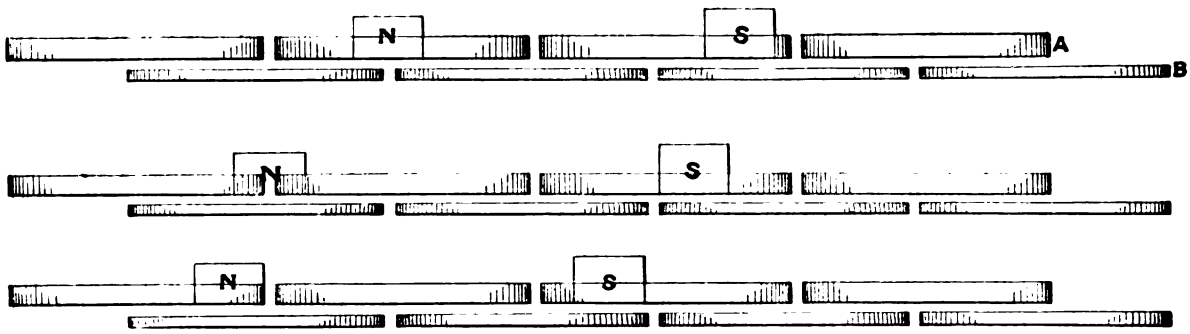
the main wave under the car might perhaps produce a subsidiary wave, rising up, say, 100 yards behind the car and making contact. But he could not produce such contact, although he had tried in many ways, such as starting the car at full speed and suddenly stopping it. The residual magnetism did not prolong the contact. In his experiments the voltage was 230 volts, but as far as he could judge at present, the line was perfectly safe for 300 volts. With reference to the insulation, the diagrams showed the line as actually built, but Mr. Lineff had since improved the general arrangements, by which he now expected to get a very much higher insulation. There was absolutely no noise with this system. Mechanical cleaning brushes were used; they were put on at an angle something like the cow-catchers on locomotives. Mr. Lineff told him that the cost of his plant, in addition to the ordinary tram line, was £2,000 per mile, which was a little heavier than an overhead conductor.



Figs. 2 to 4.—Diagrams of the magnetic condition of the rails for three positions of the Electro-magnet.

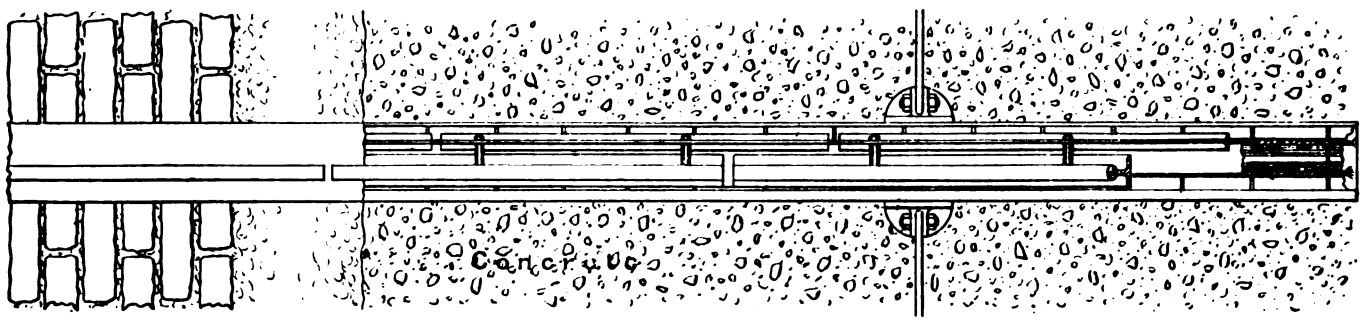


Fig. 5.—Plan of Track.

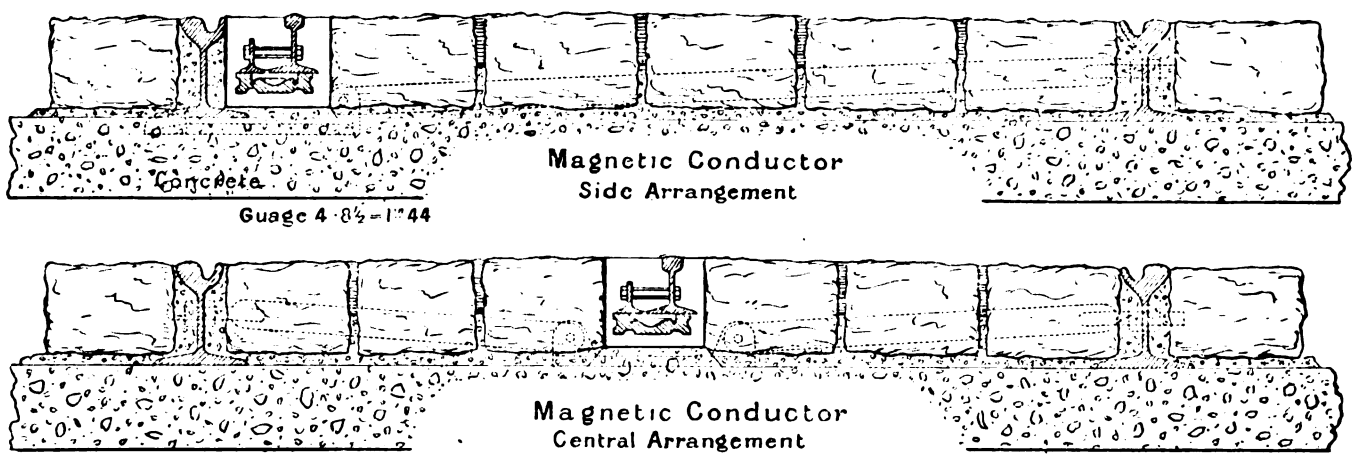


Fig. 6.—Cross-Section of Track.

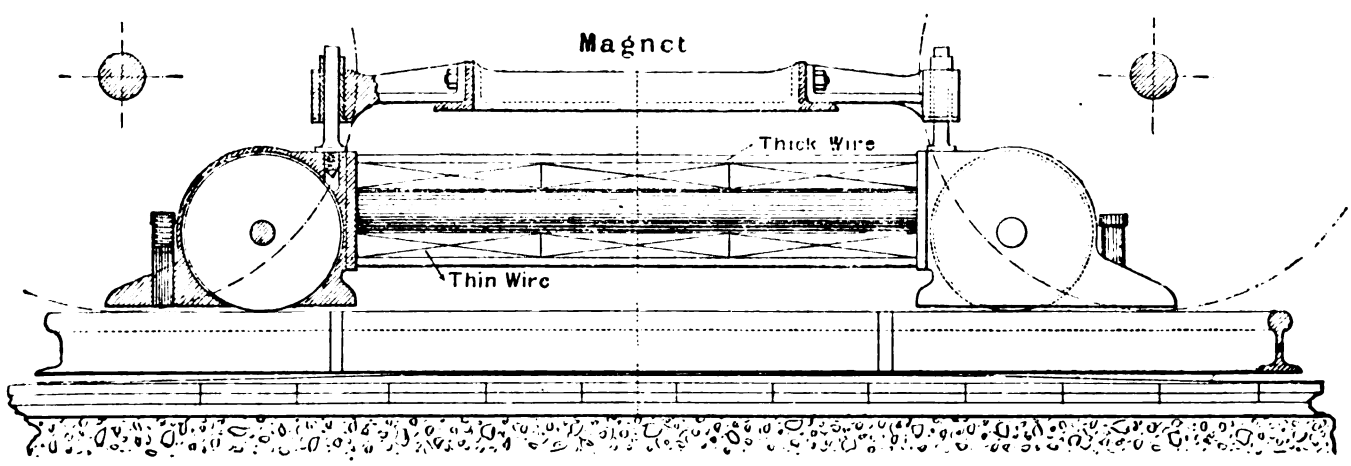


Fig.. 7—Longitudinal Section of the Line and Electro-magnet.

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DR. GLAISHER'S PRESIDENTIAL ADDRESS IN SECTION A.*

No one who is called upon to preside over this Section can fail to be struck by the range of subjects comprehended within its scope. The field assigned to us extends from the most exact of all knowledge, the sciences of number, quantity, and position, to branches of inquiry in which the progress has been so slight that they still consist of little more than collections of observed facts. This breadth of area has obvious disadvantages, but it is not without some compensating advantages. In these days, when science is so much subdivided, it is well that students of subjects even so diverse as those with which we have to deal should occasionally meet on common ground, and have the opportunity of learning from each other's lips the kind of work in which they are engaged. Wide as is our range, we should remember also how closely knit together in various ways are the more important of our subjects; and in the case of mathematics, astronomy, and physics, besides their actual and historical alliance, a mathematician may be permitted to feel that a special bond of union is created by the mathematical processes and language which are essential for their investigation and expression. It is, I am afraid, unfortunate for my audience, that my own subject should be at one extreme, not only of those dealt with by our Section, but even of the still greater range covered by the Association. I will endeavour, however, in my remarks to confine myself to a few general considerations relating to pure mathematics which I hope will not be considered out of place on this occasion.

By pure mathematics, I do not mean the ordinary processes of algebra, differential and integral calculus, &c., which every worker in the so-called mathematical sciences should have at his command. I refer to the abstract sciences which do not rest upon experiment in the ordinary sense of the term, their fundamental principles being derived from observations so simple as to be more or less axiomatic. To this class belong the theories of magnitude and position, the former including all that relates to quantity, whether discrete or continuous, and the latter including all branches of geometry. Nor would I willingly undervalue the interest of those branches of mathematics which we owe to the mathematical necessities of physical inquiry. But it always appears to me that there is a certain perfection, and also a certain luxuriance and exuberance in the pure sciences which have resulted from the unaided, and I might almost say, inspired genius of the greatest mathematicians, which is conspicuously absent from most of the investigations which have had their origin in the attempt to forge the weapons required for research in the less abstract sciences. We do not find the easy flow or homogeneity of form which is characteristic of a mathematical theory properly so called. In such a theory, as—for example—the theory of double periodicity (elliptic functions) the subject develops itself naturally as it proceeds; one group of results leads spontaneously to another; new and unexpected prospects open of themselves; ideas the most novel and striking, which penetrate the mind with a charm of their own, spring directly out of the subject itself. We are surprised by the wonderful connections with other subjects, which unexpectedly start into existence, and by the widely different methods of arriving at the same truths; in fact, as our knowledge progresses, we continually find that results which seemed to lie far away in the interior of the subject—so remote and concealed that, at first sight, we might think that no other path except the one actually pursued could have reached them—are actually close to its edge when approached from another side or viewed from another standpoint. We notice, too, that any great theory gives rise to its own special analysis or algebra, frequently connecting together into one whole what were hitherto merely isolated and apparently independent analytical results and affording a reason for their existence, and also—what is often even more interesting—a reason for the non-occurrence of others, which analogy might have led us to expect. I do not pretend that there are not many branches of mathematics which partake of both these characters, nor do I suppose that the description I have given of a mathematical theory is at all peculiar to pure mathematics. Much of it is common to all scientific research in a fruitful field, though possibly we may not find elsewhere such profusion of ideas or perfection of form.

I have been tempted to speak at such length on the objects and aims of the mathematician by the feeling that they are not infrequently misunderstood by the workers in the less abstract sciences. I do not think that mathematical formulæ or processes, merely as such, are much more interesting to the pure than to the applied mathematician. The one studies number, quantity, and position, the other deals with matter and motion; and in both cases the investigations are carried on by means of the same symbolic language.

The order in which the subjects which form an ordinary mathematical course are presented to the student is regulated by the fact that portions of the elements of the pure sciences are required for the explanation and development of any exact science; for example, a knowledge of the elements of trigonometry, analytical geometry, and differential and integral calculus, must necessarily precede any adequate treatment of mechanics, light, or electricity. The majority of students, after mastering a sufficient amount of pure mathematics to enable them to pass on to the physical subjects, continue to devote their attention to the latter, and never know more of the nature of the pure sciences than they can derive from the processes and methods which they learned at the very outset of their mathematical studies. Most of the mathematical text-books in use at Cambridge are so admirably adapted to the purposes for which they are intended that it seems ungracious to make an adverse criticism of a general kind. But I cannot help feeling regret that their writers have had so much in view the immediate application of the principles of the pure subjects to the treatment of physical problems. In the case of the differential and integral calculus, for example, there seems an increasing tendency to introduce into the bookwork and examples propositions which really belong to the physical subjects. This is an important tribute to the growth and influence of physical mathematics in this country, and a zealous physicist might even consider it satisfactory that the student should not be required to encumber himself with knowledge which was not directly applicable to the theory of matter. But from the mathematician's point of view it is unfortunate; for, while shortening by very little the path of the student, it cannot fail to give an incomplete, if not erroneous, idea of the relations of the pure to the applied sciences. How can he help feeling that the former are merely ancillary to the latter when he finds that the mathematical problems which arise naturally in physical investigations have been already dealt with out of their place in the treatises which should have been devoted solely to the sciences of quantity and position?

Passing to the consideration of pure mathematics itself, that is to say, of the abstract sciences, which can only be conquered and explored by mathematical methods, it is difficult not to feel somewhat appalled by the enormous development they have received in the last fifty years. The mass of investigation, which is annually added to the literature of the subject, is so great that it is fast becoming bewildering from its mere magnitude. To those who believe, if any such there are, that mathematics exist for the sake of its applications to the concrete sciences, it must indeed seem that it has long since run wild, and expanded itself into a thousand useless extravagances. Even the mathematician must sometimes ask himself the questions—not unfrequently put to him by his friends—"To what is it all tending? What will be the result of it all? Will there be anyend?" The last question is readily answered. There certainly can be no end; so wide and so various are the subjects of research, so interesting and fascinating the results, so wonderful the fields of research laid open at each succeeding advance—no matter in what direction—that we may be sure that, while the love of learning and knowledge continue to exist in the human mind, there can be no relaxation of our efforts to penetrate still further into the mysterious worlds of abstract truth which lie so temptingly spread before the investigator. This wonderful suggestiveness is itself one of the marks of a true theory, one of the signs by which we know that we are investigating the actual, existing truths of nature, and that our symbols and formulæ are expressing facts quite independent of themselves, though decipherable only by their means.

Instead of attempting to consider the general question of what may be expected to result from the progress of mathematical science, we may restrict ourselves to asking whether the great extension of the bounds of the subject which is taking place in our time, will materially add to its powers as a weapon of research in the concrete subjects. For my own part I do not think that the bearing of the modern developments of mathematics upon the physical sciences is likely to be very direct or immediate. It would indeed be rash to assert that there is any branch of mathematics so abstract or so recondite, that it might not at any moment find an application in some concrete subject; still it seems to me that if the extension of the pure sciences could only be justified by the value of their applications, it is very doubtful whether a satisfactory plea for any further developments could be sustained. There is a general resemblance of style running through much of the analysis required in the physical sciences, but there is no such resemblance in the case of the pure sciences or between the pure and the physical sciences. It appears likely, therefore, that in the future, the mathematical obstacles which present themselves in physical research will have to be overcome, as heretofore, by means of investigations undertaken for the purpose, and that analysis will continue to be enriched by conceptions and results and even by whole subjects (such as spherical harmonies), which will be entirely due to the concrete sciences. Of course, it will sometimes happen that a differential equation or an integral has already been considered in connection with some other theory, or a whole body of analysis or geometry will suddenly be found to admit of a physical interpretation; but, after all, even the pure sciences themselves exert but an indirect effect upon the perfection of mathematical formulæ and processes, and we must be prepared to find that in general the requirements of physics have to be met by special analytical researches. Having now endeavoured to consider the proposed question impartially, and from a cold and rational standpoint, I cannot refrain from adding that, in spite of all I have said, I believe that every mathematician must cherish in his heart the conviction that at any moment some special analysis, devised in connection with a branch of pure mathematics, may bear wonderful fruit in one of the applied sciences, giving short and complete solutions of problems which could hitherto be treated only by prolix and cumbrous methods.

It would seem at first sight as if the rapid expansion of the region of mathematics must be a source of danger to its future progress. Not only does the area widen, but the subjects of study increase rapidly in number, and the work of the mathematician tends to become more and more specialised. It is, of course, merely a brilliant exaggeration to say that no mathematician is able to understand the work of any other mathematician, but it is certainly true that it is daily becoming more and more difficult for a mathematician to keep himself acquainted, even in a general way, with the progress of any of the branches of mathematics except those which form the field of his own labours. It rests with the worker in mathematics not only to explore new truths, but to devise the language by which they may be discovered and expressed; and the genius of a great mathematician displays itself no less in the notation he invents for deciphering his subject than in the results attained. There are some theories in which the notation seems to arise so simply and naturally out of the subject itself, that it is difficult to realise that it could have required any creative power to produce it; but it may well have happened that in these

* Abstract of Address delivered before British Association at Leeds, September, 1890.

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very cases it was the discovery of the appropriate notation which gave the subject its first real start, and rendered it amenable to effective treatment. When the principles that underlie a theory have been well grasped, the proper notation almost necessarily suggests itself, if it has not been already discovered; but some sort of provisional notation is required in the early stages of a theory in order to make any progress at all, and the mathematician who first gains a real insight into the nature of a subject is almost sure to be the first to seize upon the right notation.

Quite distinct from the theoretical question of the manner in which mathematics will rescue itself from the perils to which it is exposed by its own prolific nature is the practical problem of finding means of rendering available for the student the results which have been already accumulated, and making it possible for a learner to obtain some idea of the present state of the various departments of mathematics. This is a problem which is common to all rapidly moving branches of science, although the difficulties are increased in the case of mathematics by its wide extent and the comparative smallness of the audience addressed. The great mass of mathematical literature will be always contained in journals and transactions, but there is no reason why it should not be rendered far more useful and accessible than at present by means of treatises or higher text-books. The whole science suffers from want of avenues of approach, and many beautiful branches of mathematics are regarded as difficult and technical merely because they are not easily accessible. Ten years ago I should have said that even a bad treatise was better than none at all. I do not say that now—the number of excellent text-books of an elementary kind that are published in this country makes it all the more to be regretted that we have so few that are intended for the more advanced student. As an example of the higher kind of text-book, the want of which is so badly felt in many subjects, I may mention the second part of Prof. Chrystal's Algebra published last year, which in a small compass gives a great mass of valuable and fundamental knowledge that has hitherto been beyond the reach of an ordinary student, though in reality lying so close at hand.

Although it may not be possible to contemplate the actual position of pure mathematics in this country with any great amount of enthusiasm, we may yet feel some satisfaction in reflecting that there is more cause for congratulation at present than there has been at any time in the last hundred and fifty years, and that we are far removed from the state of affairs which existed before the days of Cayley and Sylvester. Unfortunately, we cannot point with pride to any distinct school of the pure sciences corresponding to the Cambridge school of mathematical physics, and I am afraid that the old saying that we have generals without armies is as true as ever. For this there is no immediate remedy; a school must grow up gradually of itself, as the study of mathematical physics has grown up at Cambridge. I certainly should not wish, even if it were possible, to obtain more recruits for the pure sciences at the expense of the applied, nor do I desire to see the system of instruction which has found favour in this country so modified that pure mathematics could be carried on by narrow specialists. I should be sorry, for example, that a student, after learning algebra and differential calculus, should pass directly to the theory of curves, and devote himself to research in this field without ever having acquired a general knowledge of other branches of mathematics or of any of its applications. If the student were brought by the shortest possible route to the frontier of one of the subjects, where a fruitful field of research was pointed out to him, there is no doubt that the amount of mathematical literature produced might be greatly increased, but I am sure that the advantage to science would not be proportional to this increased amount. I am convinced that no one should devote himself to the abstract sciences unless he feels strongly drawn to them by his tastes.

Before leaving this part of my subject I should like to say a few words upon the subject of accuracy of form in the presentation of mathematical results. In other branches of science, where quick publication seems to be so much desired, there may possibly be some excuse for giving to the world slovenly or ill-digested work, but there is no such excuse in mathematics. The form ought to be as perfect as the substance and the demonstrations as rigorous as those of Euclid. The mathematician has to deal with the most exact facts of nature, and he should spare no effort to render his interpretation worthy of his subject, and to give to his work its highest degree of perfection. "*Pauca sed matura*" was Gauss's motto. I do not presume to assert that the interest taken in the pure sciences can be regarded as an index of the energy and power of a nation, but it is certain that mathematical research flourishes only in a vigorous community. The search after abstract truth for its own sake, without the smallest thought of practical application or return in any form, and the yearning desire to explore the unknown, are signs of the vitality of a people, which are among the first to disappear when decay begins.

THE ELECTRO-MAGNET.[1]

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

Introductory.

Amongst the great inventions which have originated in the lecture room in which we are met are two of special interest to electricians—the application of gutta percha to the purpose of submarine telegraph cables, and the electro-magnet. This latter invention was first publicly described, from the very platform on which I stand, on May 23, 1825, by William Sturgeon, whose Paper is to be found in the volume of the *Transactions* of the Society of Arts for that year. For this invention we may rightfully claim the very highest place. Electrical engineering—the latest and most vigorous offshoot of applied science—embraces many branches. The dynamo for generating electric currents, the motor for transforming their energy back into work, the arc lamp, the electric bell, the telephone, the recent electro-magnetic machinery for coal mining, for the separation of ore, and many other electro-mechanical contrivances come within the purview of the electrical engineer. In every one of these, and in many more of the useful applications of electricity, the central organ is an electro-magnet. By means of this simple and familiar contrivance—an iron core surrounded by a copper wire coil—mechanical actions are produced at will, at a distance, under control, by the agency of electric currents. These mechanical actions are known to vary with the mass, form, and quality of the iron core, the quantity and disposition of the copper wire wound upon it, the quantity of electric current circulating around it, the form, quality, and distance of the iron armature upon which it acts. But the laws which govern the mechanical action in relation to these various matters are by no means well known, and, indeed, several of them have long been a matter of dispute. Gradually, however, that which has been vague and indeterminate becomes clear and precise. The laws of the steady circulation of electric currents, at one time altogether obscure, were cleared up by the discovery of the famous law of Ohm. Their extension to the case of rapidly-interrupted currents, such as are used in telegraphic working, was discovered by Helmholtz; whilst to Maxwell is due their further extension to alternating, or, as they are sometimes called, undulatory currents. All this was purely electric work. But the law of the electro-magnet was still undiscovered; the magnetic part of the problem was still buried in obscurity. The only exact reasoning about magnetism dealt with problems of another kind; it was couched in language of a misleading character; for the practical problems connected with the electro-magnet it was worse than useless. The doctrine of two magnetic fluids distributed over the end surfaces of magnets, under the sanction of the great names of Coulomb, of Poisson, and of Laplace, had unfortunately become recognised as an accepted part of science, along with the law of inverse squares. How greatly the progress of electro-magnetic science has been impeded and retarded by the weight of these great names it is impossible now to gauge. We now know that for all purposes, save only those whose value lies in the domain of abstract mathematics, the doctrine of the two magnetic fluids is false and misleading. We know that magnetism, so far from residing on the end or surface of the magnet, is a property resident throughout the mass; that the internal not the external magnetisation is the important fact to be considered; that the so-called free magnetism on the surface is, as it were, an accidental phenomenon; that the magnet is really most highly magnetised at those parts where there is least surface magnetisation; finally, that the doctrine of surface distribution of fluids is absolutely incompetent to afford a basis of calculation such as is required by the electrical engineer. He requires rules to enable him not only to predict the lifting power of a given electro-magnet, but also to guide him in designing and constructing electro-magnets of special forms suitable for the various cases that arise in his practice. He wants in one place a strong electro-magnet to hold on to its armature like a limpet to its native rock; in another case he desires a magnet having a very long range of attraction, and wants a rule to guide him to the best design; in another he wants a special form having the most rapid action attainable; in yet another he must sacrifice everything else to attain maximum action with minimum weight. Toward the solution of such practical problems as these the old theory of magnetism offered not the slightest aid. Its array of mathematical symbols was a mockery. It was as though an engineer asking for rules to enable him to design the cylinder and piston of an engine were confronted with receipts how to estimate the cost of painting it.

Gradually, however, new light dawned. It became customary, in spite of the mathematicians, to regard the magnetism of a magnet as something that traverses or circulates around a definite path, flowing more freely through such substances as iron than through other relatively non-magnetic materials. Analogies between the flow of electricity in an electrically-conducting circuit, and the passage of magnetic lines of force through circuits possessing magnetic conductivity, forced themselves upon the minds of experimenters, and compelled a mode of thought quite other than the previously accepted. So far back as 1821, Cumming[2] experimented on magnetic conductivity. The idea of a magnetic circuit was more or less familiar to Ritchie,[3] Sturgeon,[4] Dove,[5] Dub,[6] and De La Rive,[7]

[1] A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

[2] *Camb. Phil. Trans.*, April 2, 1821.

[3] *Phil. Mag.*, Series III., Vol. III., p. 122.

[4] *Ann. of Electr.*, XII., p. 217.

[5] *Pogg. Ann.*, XXIX., p. 462, 1833. *See also Pogg. Ann.*, XLIII., p. 517, 1838.

[6] "Dub. Elektromagnetismus" (ed. 1851), p. 401; and *Pogg. Ann.*, XC., p. 440, 1853.

[7] De La Rive, "Treatise on Electricity" (Walker's translation), Vol. I, p. 292.

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the last-named of whom explicitly uses the phrase, "a closed magnetic circuit." Joule[8] found the maximum power of an electro-magnet to be proportional to "the least sectional area of the entire magnetic circuit," and he considered the resistance to induction as proportional to the length of the magnetic circuit. Indeed, there are to be found scattered in Joule's writings on the subject of magnetism, some five or six sentences, which, if collected together, constitute a very full statement of the whole matter. Faraday[9] considered that he had proved that each magnetic line of force constitutes a closed curve; that the path of these closed curves depended on the magnetic conductivity of the masses disposed in proximity; that the lines of magnetic force were strictly analogous to the lines of electric flow in an electric circuit. He spoke of a magnet surrounded by air being like unto a voltaic battery immersed in water or other electrolyte. He even saw the existence of a power, analogous to that of electro-motive force in electric circuits, though the name, "magneto-motive force," is of more recent origin. The notion of magnetic conductivity is to be found in Maxwell's great treatise (Vol. II., p. 51), but it is only briefly mentioned. Rowland,[10] in 1873, expressly adopted the reasoning and language of Faraday's method in the working out of some new results on magnetic permeability, and pointed out that the flow of magnetic lines of force through a bar could be subjected to exact calculation; the elementary law, he says, "is similar to the law of Ohm." According to Rowland, the "magnetising force of helix" was to be divided by the "resistance to the lines of force;" a calculation for magnetic circuits which every electrician will recognise as precisely as Ohm's law for electric circuits. He applied the calculations to determine the permeability of certain specimens of iron, steel, and nickel. In 1882[11] and again in 1883, Mr. R. H. Bosanquet[12] brought out at greater length a similar argument, employing the extremely apt term "Magneto-motive Force," to connote the force tending to drive the magnetic lines of induction through the "magnetic resistance" of the circuit. In these Papers the calculations are reduced to a system, and deal not only with the specific properties of iron, but with problems arising out of the shape of the iron. Bosanquet shows how to calculate the several resistances of the separate parts of the circuit, and then add them together to obtain the total resistance of the magnetic circuit.

Prior to this, however, the principle of the magnetic circuit had been seized upon by Lord Elphinstone and Mr. Vincent, who proposed to apply it in the construction of the dynamo-electric machines. On two occasions[13] they communicated to the Royal Society the results of experiments to show that the same exciting current would evoke a larger amount of magnetism in a given iron structure, if that iron structure formed a closed magnetic circuit, than if it were otherwise disposed.

In recent years the notion of the magnetic circuit has been vigorously taken up by the designers of dynamo-machines, who indeed base the calculation of their designs upon this all-important principle. Having this, they need no laws of inverse squares of distances, no magnetic moments, none of the elaborate expressions for surface distribution of magnetism, none of the ancient paraphernalia of the last century. The simple law of the magnetic circuit and a knowledge of the properties of iron is practically all they need. About four years ago, much was done by Mr. Gisbert Kapp[14] and by Drs. J. and E. Hopkinson[15] in the application of these considerations to the design of dynamo machines, which previously had been a matter of empirical practice. To this end the formulæ of Prof. Forbes[16] for calculating magnetic leakage, and the researches of Profs. Ayrton and Perry[17] on magnetic shunts, contributed a not unimportant share. As the result of the advances made at that time, the subject of dynamo design was reduced to an exact science.

It is the aim and object of the present course of lectures to show how the same considerations which have been applied with such great success to the subject of the designing of dynamo-electric machines may be applied to the study of the electro-magnet. The theory and practice of the design and construction of electro-magnets will thus be placed, once for all, upon a rational basis. Definite rules will be laid down for the guidance of the constructor, directing him as to the proper dimensions and form of iron to be chosen, and as to the proper size and amount of copper wire to be wound upon it in order to produce any desired result.

First, however, a historical account of the invention will be given, followed by a number of general considerations respecting the uses and forms of electro-magnets. These will be followed by a discussion of the magnetic properties of iron and steel and other materials; some account being added of the methods used for determining the magnetic permeability of various brands of iron at different degrees of saturation. Tabular information is given as to the results found by different observers. In connection with the magnetic properties of iron the phenomenon of magnetic hysteresis is also described and discussed. The principle of the magnetic circuit is then discussed with numerical examples, and a number of experimental data respecting the performance of electro-magnets are adduced, in particular those bearing upon the tractive power of electro-magnets. The law of traction between an electro-magnet and its armature is then laid down, followed by the rules for predetermining the iron cores and copper coils required to give any prescribed tractive force. The rules for calculating the winding of the copper coils are explained, and the limiting relation between the magnetising power of the coil and the heating effect of the current in it is explained. Then comes the extension of the calculation of the magnetic circuit to those cases where there is an air gap between the poles of the magnet and the armature; and where, in consequence, there is leakage of the magnetic lines from pole to pole. After this comes a detailed discussion of the special varieties of form that must be given to electro-magnets in order to adapt them to special services. Those which are designed for maximum traction, for quickest action, for longest range, for greatest economy when used in continuous daily service, for working in series with constant current, for use in parallel at constant pressure, and those for use with alternate currents, are separately considered.

Lastly, some account is given of the various forms of electro-magnetic mechanism which have arisen in connection with the invention of the electro-magnet. The plunger and coil is specially considered as constituting a species of electro-magnet adapted for a long range of motion. Modes of mechanically securing long range for electro-magnets, and of equalising their pull over the range of motion of the armature, are also described. The analogies between sundry electro-mechanical movements and the corresponding pieces of ordinary mechanism are traced out. The course is concluded by a consideration of the various modes of preventing or minimising the sparks which occur in the circuits in which electro-magnets are used.

Historical Sketch.

The effect which an electric current, flowing in a wire, can exercise upon a neighbouring compass needle was discovered by Oersted in 1820.[18] This first announcement of the possession of magnetic properties by an electric current was followed speedily by the researches of Ampere,[19] Arago,[20] Davy,[21] and by the devices of several other experimenters, including De la Rive's[22] floating battery and coil, Schweigger's[23] multiplier, Cumming's[24] galvanometer, Faraday's[25] apparatus for rotation of a permanent magnet, Marsh's[26] vibrating pendulum, and Barlow's[27] rotating star-wheel. But it was not until 1825 that the electro-magnet was invented. Davy had, indeed, in 1821 surrounded with temporary coils of wire the steel needles upon which he was experimenting, and had shown that the flow of electricity around the coil could confer magnetic power upon the steel needles. But from this experiment it was a grand step forward to the discovery that a core of soft iron, surrounded by its own appropriate coil of copper, could be made to act not only as a powerful magnet, but as a magnet whose power could be turned on or off at will, could be augmented to any desired degree, and could be set into action and controlled from a practically unlimited distance.

The electro-magnet, in the form which can first claim recognition for these qualities, was devised by William Sturgeon,[28] and is de-

[8] *Ann. of Electr.*, IV., 39, 1839; V., 195, 1841; and "Scientific Papers," pp. 8, 34, 35, 36.

[9] "Experimental Researches," Vol. III., Art. 3,117, 3,223, 3,230, 3,260, 3,271, 3,276, 3,294, and 3,361.

[10] *Phil. Mag.*, Series IV., Vol. XLVI., August, 1873, "On Magnetic Permeability and the Maximum of Magnetism of Iron, Steel, and Nickel."

[11] *Proc.* Roy. Soc., XXXIV., p. 445, December, 1882.

[12] *Phil. Mag.*, Series V., Vol. XV., p. 205, March, 1883. "On Magneto-Motive Force." Also *ib.*, Vol., XIX., February, 1885, and *Proc.* Roy. Soc., No. 223, 1883. See also *The Electrician*, XIV., p. 291, February 14th, 1885.

[13] *Proc.* Roy. Soc., XXIX., p. 292, 1879, and XXX., p. 287, 1880. See *Electrical Review*, VIII., p. 134, 1880.

[14] *The Electrician*, Vols. XIV., XV., and XVI., 1885-6; also *Proc.* Inst. Civil Engineers, LXXXIII., 1885-6; and *Jour.* Soc. Tel. Eng., XV., 524, 1886.

[15] *Phil. Trans.*, 1886, part I., p. 331; and *The Electrician*, XVIII., pp. 39, 63, 86, 1886.

[16] *Jour.* Soc. Tel. Eng., XV., 555, 1886.

[17] *Jour.* Soc. Tel. Eng., XV., 530, 1886.

[18] See Thomson's "Annals of Philosophy," Oct., 1820.

[19] *Ann. de Chim. et de Physique*, xv., 59 and 170, 1820.

[20] *ib.*, xv., 93, 1820.

[21] *Phil. Trans.*, 1821.

[22] "Bibliothèque Universelle," March, 1821.

[23] *ib.*

[24] *Camb. Phil. Trans.*, 1821.

[25] "Quarterly Journal of Science," Sept., 1821.

[26] Barlow's "Magnetic Attractions," second edition, 1823.

[27] *ib.*

[28] William Sturgeon, the inventor of the electro-magnet, was born at Whittington, in Lancashire, in 1783. Apprenticed as a boy to the trade of a shoemaker, at the age of nineteen he joined the Westmoreland Militia, and two years later enlisted into the Royal Artillery, thus gaining the chance of learning something of science, and having leisure in which to

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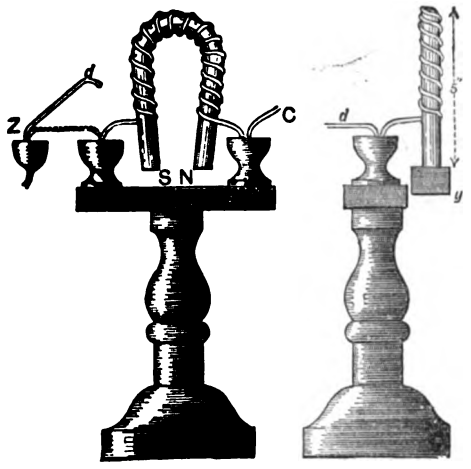
scribed by him in the Paper which he contributed to the *Proceedings* of the Society of Arts in 1825, accompanying a set of improved apparatus for electro-magnetic experiments.[29] Amongst this set of apparatus are two electro-magnets, one of the horseshoe shape (Figs. 1 and 2) and one a straight bar (Fig. 3). It will be seen that the former figures represent an electro-magnet consisting of a bent iron rod about one foot long and half an inch in diameter, varnished over and then coiled with a single left-handed spiral of stout uncovered copper wire of 18 turns. This coil was found appropriate to the particular battery which Sturgeon preferred, namely, a single cell containing a spirally enrolled pair of zinc and copper plates of large area (about 130 square inches) immersed in acid; which cell, having small internal resistance, would yield a large quantity of current when connected to a circuit of small resistance. The ends of the copper wire were brought out sideways and bent down so as to dip into two deep connecting cups, marked Z and C, fixed upon a wooden stand. These cups, which were of wood, served as supports to hold up the electro-magnet, and having mercury in them, served



FIGS. 1 and 2.—Sturgeon's First Electro-magnet.

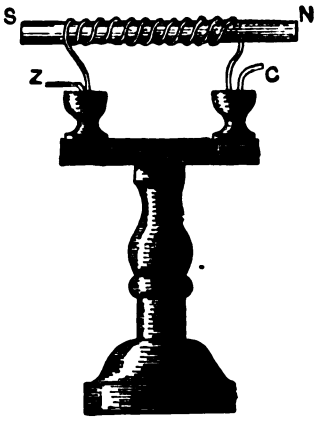


FIG. 3.—Sturgeon's Straight-Bar Electro-magnet.

also to make good electrical connection. In Fig. 2 the magnet is seen sideways, supporting a bar of iron, *y*. The circuit was completed to the battery through a connecting wire, *d*, which could be lifted out of the cup Z, so breaking circuit when desired, and allowing the weight to drop. Sturgeon added in his explanatory remarks that the poles N. and S. of the magnet will be reversed if you wrap the copper wire about the rod as a right-handed screw, instead of a left-handed one, or, more simply, by reversing the connections with the battery, by causing the wire that dips into the Z cup to dip into the C cup, and *vice versâ*. This electro-magnet was capable of supporting 9lb. when thus excited.

Fig. 3 shows another arrangement to fit on the same stand. This arrangement communicates magnetism to hardened steel bars, as soon as they are put in, and renders soft iron within it magnetic during the time of action; it only differs from Figs. 1 and 2 in being straight, and thereby allows the steel or iron bars to slide in and out.

For this piece of apparatus and other adjuncts accompanying it, all of which are described in the Society's "Transactions" for 1825, Sturgeon was awarded the Society's silver medal and a premium of 30gs. for his labours. The apparatus was deposited in the museum of the Society, which therefore might be supposed to be the proud possessor of the first electro-magnet ever constructed. Alas for the vanity of human affairs! The Society's museum of apparatus has long been dispersed, this priceless relic having been either made over to the now defunct Patent-office Museum, or knocked down under the hammer of the auctioneer for a few paltry halfpence.

Sturgeon's first electro-magnet, the core of which was only about 7oz., was able to sustain a load of 9lb., or about 20 times its own weight. At the time it was considered a truly remarkable performance. Its single layer of stout copper wire was well adapted to the battery employed, a single cell of Sturgeon's own particular construction having a surface of 130 square inches, and therefore of small internal resistance. Subsequently, in the hands of Joule, the same electro-magnet sustained a load of 50lb., or about 114 times its own weight. Writing in 1832 about his apparatus of 1825, Sturgeon used the following magniloquent language:—

"When first I showed that the magnetic energies of a galvanic conducting wire are more conspicuously exhibited by exercising them on soft iron than on hard steel, my experiments were limited to small masses—generally to a few inches of rod iron about half an inch in diameter. Some of these pieces were employed while straight, and others were bent into the form of a horse-shoe magnet, each piece being encompassed by a spiral conductor of copper wire. The magnetic energies developed by these simple arrangements are of a very distinguished and exalted character, as is conspicuously manifested by the suspension of a considerable weight at the poles during the period of excitation by the electric influence.

"An unparalleled transiliency of magnetic action is also displayed in soft iron by an instantaneous transition from a state of total inactivity to that of vigorous polarity, and also by a simultaneous reciprocity of polarity in the extremities of the bar—versatilities in this branch of physics for the display of which soft iron is pre-eminently qualified, and which by the agency of electricity become demonstrable with the celerity of thought, and illustrated by experiments the most splendid in magnetics. It is, moreover, abundantly manifested by ample experiments, that galvanic electricity exercises a superlative degree of excitation on the latent magnetism of soft iron, and calls for its recondite powers with astonishing promptitude, to an intensity of action far surpassing anything which can be accomplished by any known application of the most vigorous permanent magnet, or by any other mode of experimenting hitherto discovered. It has been observed, however, by experimenting on different pieces selected from various sources, that, notwithstanding the greatest care be observed in preparing them of a uniform figure and dimensions, there appears a considerable difference in the susceptibility which they individually possess of developing the magnet powers, much of which depends upon the manner of treatment at the forge, as well as upon the natural character of the iron itself.[30]

"The superlative intensity of electro-magnets and the facility and promptitude with which their energies can be brought into play, are qualifications admirably adapted for their introduction into a variety of arrangements in which powerful magnets so essentially operate, and perform a distinguished part in the production of electro-magnetic rotations; whilst the versatilities of polarity of which they are susceptible are eminently calculated to give a pleasing diversity in the exhibition of that highly interesting class

pursue his absorbing passion for chemical and physical experiments. He was forty-two years of age when he made his great, though at the time unrecognised, invention. At the date of his researches in electro-magnetism he was resident at 8, Artillery-place, Woolwich, at which place he was the associate of Marsh, and was intimate with Barlow, Christie, and Gregory, who interested themselves in his work. In 1835 he presented a Paper to the Royal Society containing descriptions, *inter alia*, of a magneto-electric machine with longitudinally-wound armature, and with a commutator consisting of half discs of metal. For some reason this Paper was not admitted to the *Philosophical Transactions*. He afterwards printed it in full, without alteration, in his volume of "Scientific Researches," published by subscription in 1850. From 1836 to 1843 he conducted the *Annals of Electricity*. He had now removed to Manchester, where he lectured on electricity at the Royal Victoria Gallery. He died at Prestwich, near Manchester, in 1850. There is a tablet to his memory in the church at Kirkby Lonsdale, from which town the village of Whittington is distant about two miles. A portrait of Sturgeon in oils, and said to be an excellent likeness, is believed to be still in existence; but all inquiries as to its whereabouts have proved unavailing. At the present moment, so far as I am aware, the scientific world is absolutely without a portrait of the inventor of the electro-magnet.

[29] *Trans.* Society of Arts, 1825, XLIII., p. 38.

[30] "I have made a number of experiments on small pieces, from the result of which it appears that much hammering is highly detrimental to the development of magnetism in soft iron, whether the exciting cause be galvanic or any other. And although good annealing is always essential, and facilitates to a considerable extent the display of polarity, that process is very far from restoring to the iron that degree of susceptibility which it frequently loses by the operation of the hammer. Cylindric rod iron of small dimensions may very easily be bent into the required form, without any hammering whatever; and I have found that small electro-magnets made in this way display the magnetic powers in a very exalted degree."

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of phenomena, and lead to the production of others inimitable by any other means."[31]

Sturgeon's further work during the next three years is best described in his own words :—

"It does not appear that any very extensive experiments were attempted to improve the lifting power of electro-magnets, from the time that my experiments were published in the 'Transactions of the Society of Arts, &c.,' for 1825, till the latter part of 1828. Mr. Watkins, philosophical instrument maker, Charing-cross, had, however, made them of much larger size than any which I had employed, but I am not aware to what extent he pursued the experiment.

"In the year 1828, Prof. Moll, of Utrecht, being on a visit to London, purchased of Mr. Watkins an electro-magnet weighing about 5lb.—at that time I believe the largest which had been made. It was of round iron, and about 1in. in diameter, and furnished with a single copper wire twisted round it 83 times. When this magnet was excited by a large galvanic surface, it supported about 75lb. Prof. Moll afterwards prepared another electro-magnet, which, when bent, was 12½in. high, 2½in. in diameter, and weighed about 26lb. ; prepared like the former with a single spiral conducting wire. With an acting galvanic surface of 11 square feet, this magnet would support 154lb., but would not lift an anvil which weighed 200lb.

"The largest electro-magnet which I have yet [1832] exhibited in my lectures weighs about 16lb. It is formed of a small bar of soft iron, 1½in. across each side ; the cross piece, which joins the poles, is from the same rod of iron, and about 3¾in. long. Twenty separate strands of copper wire, each strand about 50ft. in length, are coiled round the iron, one above another, from pole to pole, and separated from each other by intervening cases of silk ; the first coil is only the thickness of one ply of silk from the iron ; the

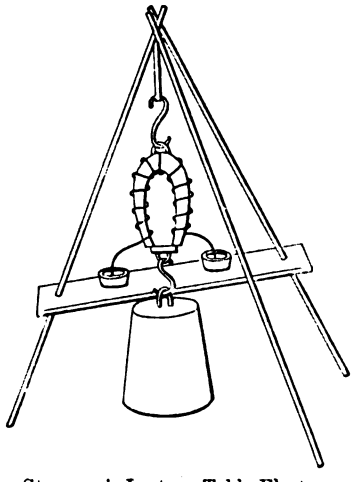

Fig. 4.—Sturgeon's Lecture Table Electro-magnet.

twentieth, or outermost, about half-an-inch from it. By this means, the wires are completely insulated from each other without the trouble of covering them with thread or varnish. The ends of wire project about 2ft. for the convenience of connection. With one of my small cylindrical batteries, exposing about 150 square inches of total surface, this electro-magnet supports 400lb. I have tried it with a larger battery, but its energies do not seem to be so materially exalted as might have been expected by increasing the extent of galvanic surface. Much depends upon a proper acid solution ; good nitric or nitrous acid, with about six or eight times its quantity of water, answers very well. With a new battery of the above dimensions and a strong solution of salt and water, at a temperature of 190° F., the electro-magnet supported between 70lb. and 80lb., when the first 17 coils only were in the circuit. With the three exterior coils alone in the circuit, it would just support the lifter, or cross-piece. When the temperature of the solution was between 40deg. and 50deg., the magnetic force excited was comparatively very feeble. With the innermost coil alone, and a strong acid solution, this electro-magnet supports about 100lb. ; with the four outermost wires about 250lb. It improves in power with every additional coil until about the twelfth but not perceptibly any further ; therefore, the remaining eight coils appear to be useless, although the last three, independently of the innermost seventeen, and at the distance of half-an-inch from the iron, produce in it a lifting power of 75lb.

"Mr. Marsh has fitted up a bar of iron much larger than mine, with a similar distribution of the conducting wires to that devised and so successfully employed by Prof. Henry. Mr. Marsh's electro-magnet will support about 560lb. when excited by a galvanic battery similar to mine. These two, I believe, are the most powerful electro-magnets yet produced in this country.

"A small electro-magnet, which I also employ on the lecture table, and the manner of its suspension, is represented by Fig. 4, Plate VI. The magnet is of cylindric rod iron, and weighs 4oz. ; its poles are about a quarter of an inch asunder. It is furnished with six coils of wire, in the same manner as the large electro-magnet before described, and will support upwards of 50lb.

"I find a triangular gin very convenient for the suspension of the magnet in these experiments. A stage, A A, of thin board, supporting two wooden dishes, C and Z, is fastened, at a proper height, to two of the legs of the gin. Mercury is placed in these vessels, and the dependent amalgamated extremities of the conducting wires dip into it—one into each portion.

"The vessels are sufficiently wide to admit of considerable motion of the wires in the mercury without interrupting the contact, which is sometimes occasioned by the swinging of the magnet and attached weight. The circuit is completed by other wires, which connect the battery with these two portions of mercury. When the weight is supported as in the figure, if an interruption be made by removing either of the connecting wires, the weight instantaneously drops on the table. The large magnet I suspend in the same way on a larger gin ; the weights which it supports are placed one after another on a square board, suspended by means of a cord at each corner from a hook in the cross piece, which joins the poles of the magnet.

"With a new battery, and a solution of salt and water, at a temperature of 190°F., the small electro-magnet (Fig. 3) supports 16lb."

In 1840, after Sturgeon had removed to Manchester, where he assumed the management of the "Victoria Gallery of Practical Science," he continued his work, and in the seventh memoir in his series of researches, he wrote as follows :—

"The electro-magnet belonging to this Institution is made of a cylindrical bar of soft iron, bent into the form of a horse-shoe magnet, having the two branches parallel to each other, and at the distance of 4 5in. The diameter of the iron is 2 75in. ; it is 18in. long when bent. It is surrounded by 14 coils of copper wire, seven on each branch. The wire which constitutes the coils is $\frac{1}{12}$th of an inch diameter, and in each coil there are about 70ft. of wire. They are united in the usual way with branch wires, for the purpose of conducting the currents from the battery. The magnet was made by Mr. Nesbit. . . . The greatest weight sustained by the magnet in these experiments is 12¼cwt., or 1,386lb., which was accomplished by 16 pairs of plates, in four groups of four pairs in series each. The lifting power by 19 pairs in series was considerably less than by 10 pairs in series ; and but very little greater than that given by one cell or one pair only. This is somewhat remarkable, and shows how easily we may be led to waste the magnetic powers of batteries by an injudicious arrangement of its elements."[32]

(To be continued.)

[31] Sturgeon's "Scientific Researches," page 113.

[32] Sturgeon's "Scientific Researches," p. 188.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *August* 29, 1890.

The Board of Electrical Control.—Matters electrical are somewhat at a standstill just at present. The Board of Electrical Control has settled down to business again, and its meetings are enlivened by the usual obstruction policy of Mayor Grant. At the last meeting it was found that one of the electric light companies had been laying conduits, for which a permit is required, for several blocks, under the guise of subsidiary docks, for which no permit is required, and the Mayor thereupon waxed wrathful.

Meeting of the American Association for the Advancement of Science.—The meeting of the American Association for the Advancement of Science, at Indianapolis, just completed, did not bring out any Papers of commanding importance. They were, as usual, rather theoretical than practical in character, and only one of them had a very marked theoretical interest ; that was a preliminary report on experiments made to determine the effect of a magnetic field on the velocity of light. The results obtained were, however, negative, but the experiments will be tried again with a more powerful field, and it is to be hoped that something definite will be learned.

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Municipal Opinions on Electric Traction.—An interesting series of questions was recently distributed to the mayors of a considerable number of American cities by one of the Boston daily papers. It bore on the electric street-car system in extensive use throughout this country, and was intended to bring out a clear and frank expression of public opinion concerning their merits. Twenty-seven replies were published a few days since, and in every case the officials addressed were unanimous in declaring the electric street-cars to be a success, to be free from any marked degree of danger, and to have done excellent work in developing outlying districts, and saving valuable time for residents of the suburbs. Public apprehension of the dangers of overhead wires seems to be very ill-founded, and is rapidly dying out. Of course, there is in certain localities a feeling that a storage or conduit system would be more agreeable; but even the large cities are very ready to take electric traction as it is, feeling that it is an enormous benefit to the public, and, like other improvements, should be taken advantage of without waiting for ideal conditions. It is a very singular fact that a number of horses have been killed by the current used on these street-car lines, generally from telephone or telegraph wires breaking and falling across the bare conductor, and thence hanging down over the street. Nevertheless, not a single person has been killed or seriously injured, although the number of shocks reported is considerable. It seems to be definitely established that the 500 volt current now in use cannot, under any ordinary conditions, do serious injury to a human being, while it is apparently pretty clear that horses are considerably more susceptible to shock. Nevertheless, it is found, even in so large a city as Boston, the overhead wires do not produce any considerable amount of apprehension, much less danger.

The Double Carbon Arc Lamp Litigation.—The Brush Company is still pursuing its patent suits vigorously. The double carbon arc lamp patent is the particular subject of legal warfare, and the Brush Company has been uniformly successful in defending it, having obtained several permanent injunctions and other temporary ones. Its suit with the Sperry Company on this issue resulted only in a temporary injunction, and the action is still going on; but in this case the Sperry Company almost immediately retaliated by bringing out what is called a triple carbon lamp, consisting of two parallel round positive carbons of the ordinary type, held rigidly parallel in the same holder, and a single oval negative carbon. The arc, of course, shifts from carbon to carbon perhaps every half hour, but inasmuch as the points of both positive carbons are intensely heated the effect of this shifting is so far modified that very little disturbance to the light is produced. The new form of lamp has a very long life of carbon and gives a uniform and excellent light.

CORRESPONDENCE.

PROF. ELIHU THOMSON'S OSCILLATING METER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your reference to my oscillating meter in your issue of August 15th there are some things which are a little misapprehended, and which I take this occasion to correct.

I would say that the oscillating body is mounted on knife edges, and is balanced so accurately that the meter may be thrown out of level without disturbing the position of the oscillating portion. In regard to the sparking on shifting the current from one fine wire coil to the other, I can state that I find very little difficulty on that score on account of the very high resistance given to the coils, and the very small current which traverses them. I use an amalgamated wire dipping into small mercury cups. There are no dash-pots in the meter, as you seem to infer. I suppose you have mistaken the mercury cups for dash-pots. The switching from one to the other is accomplished quickly by a small overbalanced lever, or, better yet, by a lever carrying an iron mass moving in a magnetic field, adjusted to cause it to move quickly from side to side, as impelled by the main oscillating body. The magnetic effect in this case permits large changes in the level of the meter to be made without affecting the throw.

You are quite right in saying that the arangement is rather a reciprocating electric motor than an electric clock. I would here say, further, that the meter has been chiefly tested on alternating currents, and that its registry is closely proportional to the load in current and not affected by the square of the current. The most remarkable feature of this meter, as it has been worked, is the extremely small energy which it can be made to run by—an amount so small, indeed, that it is entirely negligible. In one of the meters constructed, it is under five watts, with a load of 40 lamps, each consuming about 50 watts, and yet the meter was sensitive to one lamp. Another merit of the meter is that, with the requisite machinery, it can, without doubt, be made very cheaply.—Yours, &c.,

ELIHU THOMSON.

Lynn, Mass., August 27, 1890.

PROF. ELIHU THOMSON'S NEW ALTERNATING MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have noticed in your issue of August 15th a description of a dynamo machine designed by myself, printed alongside one of a machine designed by Mr. Mordey, and upon which you make certain editorial comments.

In the first place I must begin by stating that the description of my machine which you have copied is one based upon the United States Patent specification as it appeared, and that I am not in any way responsible for any comments which may have been made upon the machine as there described. If this be borne in mind you will see that the case will clear itself up somewhat. It happens to be the custom with American papers to take patent specifications as they issue and make descriptions from them, calling attention to matters found therein which in the Editor's judgment may be proper for the information of the readers. It was in this way that my electric welding inventions were first noticed under my name a number of months before I had written and published anything in connection with the matter.

Now, in regard to forms of dynamo machine, I think it can be truly said that innumerable suggestions have been made either publicly or privately covering the widest possible modifications of this important structure. To determine the question of originality in these cases it would be necessary to bring together in a sort of general concourse all inventors and designers of such machinery and compare the dates of their inventions and designs, hundreds of which I know to exist without publication. Some of the suggested forms have subsequently taken important positions in the art, frequently being reinvented or redesigned by the same or by other parties working upon this general subject. So far as I am personally concerned, I wish it to be understood that I desire to claim nothing to which I would not be justly entitled, and I should prefer to err in claiming less. I have the greatest respect for Mr. Mordey and others who have done exceedingly valuable work in the electric field; but I cannot agree with you at all in the opinion put forward in your editorial notes that the machine designed by me is a good deal behind that of the English one which you publish with it. On the contrary, the case is much the other way, and if both machines were built and run my opinion on the subject would be found to be correct. I need scarcely state that my opportunities for gaining experience in this and kindred matters have been, to say the least, considerable.

The direction of the lamination in the Mordey machine is undoubtedly at right angles to the direction which the dividing surfaces should properly take; and the fact that the iron carrying the armature coils is constantly under the influence of the magnetising field coil, and, therefore, tends to change its magnetism but little, is against working at high inductions. I need scarcely point out that the construction is a somewhat difficult one, the published figures, however, not showing the complete machine, but only its electrical elements.

In regard to the feature which is claimed for the English design, *i.e.*, that "no back volts are set up in the field coil," I

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would simply say that I have built a numbe of machines of the type you describe under my name, and found no evidence of any back electro-motive force in the field coils. In fact, if there were any back electro-motive force, it would also be accompanied by a forward electro-motive power due to the changes of magnetism in the field, and these effects would compensate each other. I would also call attention to the fact that while the figures you have published show the armature bobbins wound on projections, I have operated a machine perfectly well with bobbins without projections, in which case the induced bobbins, or what corresponds to the armature bobbins, were supported in the interior of a simple laminated ring. You will therefore see that the design may include a magnetic circuit, to which but few objections may be raised.

I am not ready to publish tests of any machines of the type referred to, as such tests are not completed. I may say, however, that I found that I could obtain an output of 75,000 watts from a machine weighing (including a heavy bedplate) 8,950lb., with indications of an efficiency not inferior to that of the best direct current machines. There is a remarkable absence of heating, showing the magnetic losses to be very small.

As a matter of interest in connection with this machine, I would add that a smaller machine has been constructed, from which it is easy to obtain a rate of alternations of over 5,000 per second or a periodicity of 2,500, to be used for experimental purposes. The machine gives 1,000 volts between its terminals. A curious fact is that arcs produced by rates of alternations so high as this are not so liable to extinction as those in which slower alternations are employed, and they are accompanied by a very high and a rather powerful musical note, the pitch of which, of course, corresponds with the periodicity. It is probable that the machine, in addition to other uses, will be employed to determine the physiological effect of such high rates of alternations.—Yours, &c., ELIHU THOMSON.

Lynn, Mass., August 27, 1890.

TESTS OF SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of September 5th appears a translated account of some tests of secondary cells as constructed by various Continental makers. The results obtained are extremely interesting, but their value is considerably discounted by the fact that one of the most important details of such tests, viz.—the rates at which the respective cells were charged and discharged, are not given; and it is impossible, therefore, to estimate from the particulars published the comparative utility and efficiency of the various types.

I would like also to point out that tests of secondary cells made for the purpose of proving the utility of various forms are utterly worthless, unless the cells have been subjected to daily charges and discharges for a period of at least six months. —Yours, &c., FRANK KING.

London, E.C., Sept. 8, 1890.

[If our correspondent will again look at the translation in question he will see that the value of the charging and discharging current is given in every case except one, viz., that of the Tudor accumulators. We quite agree with the remarks contained in the last paragraph, and the publication of the results of the first six months' working of the Chelsea Electricity Supply Company's batteries would be invaluable. ED. *E.*]

MR. PREECE'S PAPER ON "THE SANITARY ASPECTS OF ELECTRIC LIGHTING."

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—I have just had brought to my notice the report of the above Paper in your issue of the 29th, in which Mr. Preece is represented to have stated that the "efficiency of a '*high-pressure*' system of distribution which he calls '*the direct current battery is 50 per cent.*'; that '*a company working on the high-pressure battery system secured only 29 per cent.*'; lastly, he refers to '*the high-pressure battery system in Chelsea.*'"

May I secure equal publicity for the following statement, which Mr. Preece will, I am sure, be glad to endorse, namely: That the Chelsea Electricity Supply Company, which obtained, and works under, what is well known as the Chelsea Act of 1886, and which now supplies current under statutory powers in Chelsea and part of Kensington, in forty-one streets, squares, &c., of these parishes—does not use any method of supply that can be called the *high-pressure direct-current battery system*, and that its efficiency is certainly *over 75 per cent.*, and not *50 or 29 per cent.*, as the report of his Paper may be fairly supposed to imply.—Yours, &c., C. E. WEBBER, Maj.-General.

Leeds, Sept. 7, 1890.

THE ELECTRIC LIGHT AT BATH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—Having recently had a run down to Bath, and having seen the most unsatisfactory burning of the arc lamps on Saturday, August 30th, and the fiasco of August 31st, I not unnaturally turned to my *Electrician* this week expecting you would have something to say about it. Thinking you might not be in possession of the facts, I beg to forward such information as I obtained.

The arc lamps were most unsteady between 10 and 11 on Saturday, August 30th, the cause being that the engineer in charge had allowed his steam to drop from 150 to 108lb. The dynamos had slowed down until the blowing arrangement (Thomson-Houston) ceased to work, the sparks flashing round the commutator.

On Sunday evening August 31st, all the incandescent lamps were out from 8 p.m. for the remainder of the evening. Forty-eight of the public arcs were out from 8.45 until 12, and all the arc lamps (some 83) were out from 11 to 12. I met the police going into the station to report "lamps out," and went in with them. The station was in a state of semi-darkness, the men having to work with two smoky paraffin lamps and three or four candles. The stoppage was due to an inability to get water into the boilers. The injectors had been in a general state of uselessness for a month or six weeks. They were depending entirely on one little donkey-pump for their feed-water, and it had been stopped by a piece of spun yarn about the size of your fist getting jammed in the suction-pipe. There was no rose fitted to the end of that suction-pipe, and no covers to the tanks from which the feed-water was drawn.

I noticed on walking round that the whole of their high-tension fuses and switches are entirely unprotected, fitted within a few feet of the ground, and only a few inches from the boys, aged 14 to 16, who are employed to work the rheostat in the exciting circuit.

I think such carelessness and its results have been sufficiently disastrous to call for condemnation.—Yours, &c.,

CHARLES POWELL.

38, St. Martin's-street, Leicester-square, London, W.C., September 6, 1890.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

August 7, 1890.

12,381. A. L. SHEPARD. London. An improved device for facilitating the connection and disconnection of electrical conductors.

12,383. A. L. SHEPARD. London. Improvements relating to electric lamps, and to apparatus connected therewith.

August 8, 1890.

12,394. W. P. ODHIM. Portarlington. Composite brushes for electric lighting.

12,422. J. JENG. London. An electric pendulum for firing ship's guns.

12,439. A. L. SHEPARD. London. Improvements in and relating to electric lamps or lighting apparatus.

12,440. A. A. DAY and H. J. DOWSING. London. Portable combination electrical testing set.

August 9, 1890.

12,475. E. TAUSSIG. London. Improvements in electrical smelting.

12,504. E. P. ALLAM. London. Improvements in holders for incandescent electric lamps.

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August 11, 1890.

12,532. S. Pitt. London. Improvements in electric lighting (Sautter, Harlé, and Co., France).

12,562. W. O. Stanley. London. New or improved means or apparatus for generating electricity.

12,566. E. C. Russell. London. Improvements in electric arc lamps.

August 12, 1890.

12,628. H. E. Fowler. London. Improvements relating to the welding of metals by electricity.

12,634. T. M. Foote. London. Improvements in dynamo electric machines or electric motors.

August 13, 1890.

12,713. S. Ziani de Ferranti. London. Improvements in electric mains and in apparatus used in their manufacture.

August 14, 1890.

12,737. J. M. M. Munro. Glasgow. Improvements in appliances for conducting electric currents.

12,763. E. Buffet. London. Improvements in or relating to electrical batteries.

12,777. R. H. Gould and T. Gottschalk. London. Improved safety connections or couplings for electric conductors.

12,784. R. W. James. London. Improvements in underground conduits and conductors for electrical transmission (William John Brewer, United States).

August 15, 1890.

12,819. S. D. Williams. Newport. Improvements in column type printing instruments operated electrically, for telegraphic and other purposes, and in conductors therefor, which latter are also applicable for telephonic and electric transmission generally.

12,827. H. J. Hilton. London. Improvements in armatures for dynamo-electric machines.

12,830. H. H. Lake. London. Improvements in secondary batteries, and electrodes therefor. (George Augustine Johnson and Sidney Latham Holdrege, United States.)

12,832 E. Wilson. London. An electrical watt meter; also applicable as an ammeter or voltmeter.

ARTISTIC ELECTRIC LIGHT FITTINGS.

In a recent issue, reference was made to a number of admirably executed catalogues of artistic electric light fittings issued by several well-known firms of fittings makers. We have now received copies of new catalogues issued by other firms, to which we would call our readers' attention. As in our previous article, we would specially refer to the taste and originality displayed in the designs, and to their moderate cost. We cannot claim to have at all exhausted the books, nor have we yet received catalogues issued by several other firms of eminence in this department of electrical industry, but which we hope to receive for notice at an early date.

Messrs. Faraday and Son.—An artistically illustrated catalogue of 62 large folio pages has been issued this week by Messrs. Faraday and Son, in which is given a most varied array of artistic designs. We may specially note No. 63, a beautifully-chased bracket; No. 81, a silvered picture reflector for sideboard or walls; No. 67, a chased Louis XVI. sconce; Nos. 42 and 16, brackets and lanterns; No. 144, an iced-glass pine pendant; No. 162, a richly-cut bowl pendant, with chased mounts; No. 1,611, a handsome dining-room centre pendant, with chased mounts and fringe and gauze underscreen; No. 36, a beautiful electrolier with knurled stem and chased leafage; No. 171, a richly-chased corona, with cupids and shells; No. 8, an Italian Rénaïssance table standard; No. 25, a "Medusa" table standard. The catalogue also contains some very fine registered designs of classical figures, including "Iris," "Bacchus," "Cupid," and "Mercury." Only a few of the figures given in the catalogue are enumerated, and we recommend our readers to obtain a copy of the book, which is well printed and neatly bound. Messrs. Foraday and Sobs' show-rooms are situate at Berners-street, Oxford-street, London, W.

Messrs. Strode and Co.—We have recently received a catalogue from this firm, who are well known as manufacturers of high-class art metal work. A number of suspension lights, brackets, &c., are displayed, as well as many examples of really choice work, of which we may enumerate numbers 5,624, 5,164, 5,393, 5,392, and 4,961. No. 5,393 is a fifteen-light electrolier with two tiers of arms, enwrought with hammered leafage and flowers, fluted and repoussé stem and ceiling plate, and is very effective. Messrs. Strode and Co.'s show-rooms are situate at Osnaburgh-street, W.C., and St. Paul's Churchyard, E.C.

Messrs. O. Berend and Co.—The elaborate book of samples sent by this firm contains illustrations of a vast number of artistic electric light fittings in Saxonian bronze ware, for which Messrs. O. Berend and Co. are the agents in this country. Numbers 2,063, 2,064, 2,115, 2,315, 2,130, 2,141 and 2,142 may be described as suitable for heavy wear; whilst numbers 2,005, 2,091, 2,111, 2,120, 2,123, 2,143, are of most elaborate design. Many of the examples in the book are combination fittings for gas and electric light. The assortment shown is very large, and we understand that a considerable demand has already arisen for the Saxonian Bronze Ware Fittings. A number of suspension lights are illustrated in the book, whilst hall and vestibule lights, conservatory lights, brackets (many of which are very artistic in design), pillar lights (some of these again are in excellent taste), &c., make the specimen book very complete. Messrs. Berend's show-rooms are situate at 61, Fore-street, E.C.

Mr. Richard Crittall.—This gentleman has recently issued his illustrated catalogue of electric light fittings, many of which give evidence of considerable taste. We may select for special mention B 35, A 47, A 3, A 63, C 125 (a seven-light pedestal lamp), A 49, A 50, A 52, A 135, and A 101. The catalogue contains a large variety of brackets, pendants, hall lanterns, and table lamps. The fittings generally are made in wrought iron, copper, brass, and copper and brass combined, and are quoted at extremely moderate prices. A large assortment is on show at Mr. Crittall's show-rooms, 20, Baker-street, London, W.

TRADE NOTES AND NOTICES.

Tenders Wanted.—Mr. J. E. Keirby, Moorfield Villa, Swinton, near Manchester, invites tenders for fitting up a 50-light incandescent electric installation; dynamo and power already fixed.

————.The Corporation of Dublin will, on or before 5 o'clock p.m. on Monday, the 13th day of October next, receive tenders for the electric lighting of streets in the city of Dublin. The contractors will be required to build station, supply, erect, and fix all the necessary plant, machinery, engines, boilers, dynamos, conductors, pillars, &c. The specification, form of tender, and ground plan of site and streets proposed to be lighted, can be had at the office of Mr. Spencer Harty, C.E., Borough Surveyor, City Hall, Dublin. Tenders are to be addressed to Mr. John Beveridge, the Town Clerk, City Hall, Dublin. Further particulars will be found in our advertisement pages.

Removal.—Messrs. C. E. G. Gilbert and Co., Electrical Engineers and Contractors, have removed to larger premises at No. 16, Hanway-street, Oxford-street, W., where they have a spacious show-room and increased facilities for manufacturing.

The Sunbeam Lamp Company (Limited).—We have received from this Company an illustrated card, giving particulars and prices of Sunbeam lamps and lamp-holders, &c. The card includes a table giving the current required for the Sunbeam lamps, and also gives a list of sizes of lamps always in stock.

The Phospher Bronze Company (Limited).—We have received from this Company a new catalogue, giving exhaustive particulars of the manufactures of the firm. The catalogue contains a number of testimonials from large users of the Phosphor Bronze Company's products, and includes the correspondence recently appearing in our contemporary the *Engineer* upon the subject of the durability of phosphor bronze, concluding with a diagram giving the particulars of some interesting tests with Bull's patent metal, which is supplied by the Company.

"Electricity in Every Day Life."—We have received from Messrs. Goolden and Co. a well got-up popular brochure under the above title. The book is profusely illustrated, many of the engravings being of merit. It consists of 24 large octavo pages, and is on sale at the popular price of 1d. A large demand may safely be predicted.

CRICKET.

Eastern Telegraph Company v. Kenneth Anderson and Co.

This match was played at Barnes on Saturday last, and resulted in a victory for the latter firm by 22 runs, after a very enjoyable game. Mr. Kenneth Anderson very kindly offered a bat for the highest scorer on either side, and a ball to the one with the best bowling average. The Eastern Company, who were unfortunately without the services of two or three of their best men, won the toss, but made a bad start, six wickets falling for only 16 runs. Messrs. Cole and Faulkner then by means of very careful batting, carried the score to 37 before the latter was dismissed. The innings closed for 64, Mr. Cole's contribution being 30, which was made in good style. Messrs. Gurney and Jack proved the most successful bowlers, the former securing 3 wickets for 32 runs, and the latter 3 wickets for 12. With only about an hour to play Kenneth Anderson and Co. started batting, with Messrs. Gowenlock and A. Sloper, and from the first over, the former scored 10 runs, and continued to hit in vigorous style until 47 were placed to his credit (thus securing the bat), when he was bowled by Mr. Macmillan. The innings closed for 86, Kenneth Anderson and Co. winning by 22 runs. This result was in a great measure due to Mr. Gowenlock's brilliant display. Mr. Macmillan secured 6 wickets for 29 runs, going very close for the bowling prize. Mr. Cole took 2 wickets for 25, and Mr. R. E. Donaldson 1 for 7 runs. Score :—

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EASTERN TELEGRAPH COMPANY.—Mr. J. G. Macmillan b A. Jack, 3; Mr. Gardner l b w b Gurney, 3; Mr. Payton b A. Jack, 1; Mr. T. Richardson (capt.) b Gurney, 1; Mr. R. Donaldson run out, 3; Mr. W. A. Donaldson b A. Jack, 0; Mr. Faulkner run out, 11; Mr. Cole l b w b Gurney, 30; Mr. S. Wells run out, 3; Mr. McIntosh not out, 2; Mr. Penny absent, 0; byes, &c., 7. Total, 64.

KENNETH ANDERSON AND COMPANY.—Mr. J. Gowenlock b Macmillan, 47; Mr. A. Sloper b Macmillan, 1; Mr. A. Jack (capt.) b Cole, 6; Mr. H. Gurney b Macmillan, 8; Mr. J. White c and b Macmillan, 0; c. Macmillan; Mr. C. Sloper b R. Donaldson, 0; Mr. Bateman b Macmillan, 2; Mr. Granger, junr., c Donaldson b Cole, 2; Major Granger b Macmillan, 6; Mr. J. Strudwick not out, 1; Mr. G. C. Hawes absent, 0; byes, &c., 13. Total, 86.

COMPANIES' MEETINGS & REPORTS.

Brush Electrical Engineering Company (Limited).

The first annual general meeting of the Brush Electrical Engineering Company (Limited) was held at the Cannon-street Hotel, London, E.C., on Monday, September 8, 1890, to receive the report of the Directors and the accounts to June 30, 1890, and to transact the ordinary business of the Company. Lord Thurlow, F.R.S., presided.

Mr. E. GARCKE (the Manager and Secretary) read the notice calling the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: Gentlemen, as this is the first time I have had the honour of addressing you at an annual meeting of the Company, I think, perhaps, you will pardon me if I say a few words in explanation of the position which we at present occupy, and describe briefly the financial and other results of the amalgamation. In so doing I take it for granted that you would desire that I should take up as little time as is consistent with what I deem it to be my duty on the present occasion. You will recollect that the statutory meeting of this Company was held on November 25th, and on that occasion it was reported that the reconstruction of the Brush Company—that is to say, its amalgamation with the Australasian and Falcon Companies—had been satisfactorily carried out more or less at that time, still perhaps on paper. But as we stand here to-day that has assumed a practical reality. Then, as regards the reconstruction of the Anglo-American Brush Electric Light Corporation, I think there is very little more to be said beyond what you already know. We have retained, of course, our works in Belvedere-road and other works that we had. We have retained, in fact, everything that we possessed, and in addition we have acquired the valuable assets that you are aware of. New shares were issued for the old shares—that is to say, the old Brush shareholders got new shares in exchange at the agreed-upon rate of three-fifths ordinary, and two-fifths Preference. Then, as regards the Falcon business at Loughborough, I will at a later stage go at some length into a description of what those works consist of. At the present moment it will probably be sufficient for me to say that no time was lost in taking these works over, and that we immediately proceeded to spend what has turned out to be an amount of about £20,000 in erecting new shops to enable us to construct the heavy machines which we are now called upon to turn out. These shops consist chiefly of a foundry and large fitting and erecting shop. I will give you the actual measurements and details of some of these new works a little later. Then, as regards the Australasian Company, you will remember that the original scheme was that we should take over the whole of their business, including their patent rights and stores, and we were to issue to them £45,500 in shares and £500 in cash. Well, negotiations were very protracted in connection with this matter; they were protracted, not on account of the unwillingness of either party to enter into arrangements, but to the practical difficulty of assessing the value of some of the assets. However, these negotiations were satisfactorily conducted, but with a certain modification The modification was, that this Company, instead of taking over their stores and floating assets and liabilities, should take over only their patents and the shares in the Melbourne Company, and agree to issue £31,000 of fully paid-up shares to them in the same proportion as was agreed to in the ordinary and Preference shares—31,000 instead of 45,500. Then there were some subsequent negotiations following upon that, owing to the inability of the Australasian Company at the time to give a good title for everything that had been scheduled. There were one or two matters which we need not describe, matters of no material importance—at any rate, a certain deduction had to be made on that account. The final result was that we took over what I have said, the stores and patents and shares, and shares in the Melbourne Company for £27,500 in shares, in the same proportion as I have already stated—two-fifths in Preference and three-fifths in ordinary shares. Well, I think, perhaps you will allow me to say that which I have already said. There were difficult negotiations, and if it had not been for the conciliatory way in which we were met by the Chairman of that Company, Mr. Van Tromp, and by the liquidators who were carrying out the arrangement, I think the difficulties would have been so great that it might have fallen through; and I consider that that would have been unfortunate. Then, further negotiations are still taking place, because although that is the final result at which we have arrived, further negotiations are still taking place with a view to the Brush Company taking over the whole of their stores. From the first we said, and we adhere to that, that we would not take over their assets and liabilities, and from that decision we have not departed. We have consequently taken over the shares in the Melbourne Company, and practically their stores, and we have taken over their patents and all their business, not only in Australia, but in the Australasian Colonies. It has opened up for us an enormous field for business, and one which will require very considerable energy on our part to do justice to. To enable us to grasp more fully the position that we shall henceforth occupy in regard to that part of the world, we requested Captain Rowan, who was the very efficient manager of that Company for some years past, to come from Australia and advise us on all points. He came here, and we had lengthy meetings, and entered, I think, into every point that was at issue; and we have finally made satisfactory terms engaging him for a number of years, and he has gone out again to look after our interests and take charge of our business. The final outcome of the issue of shares on that amalgamation is as follows:—We have issued to the Anglo-American Brush shareholders 196,942 of ordinary shares, and 104,628 of Preference shares. We have issued to the Falcon Company 33,300 of ordinary shares, and 22,200 of Preference shares. We have issued to the Australasian Company 16,500 of ordinary shares, and 11,000 of Preference shares. The balance of capital which appears in the report and balance-sheet has been raised by subscriptions, making in all an additional £24,192 in ordinary shares, and £164 of Preference shares. Well, I think when you look at those figures, and when you see how they are represented in the balance-sheet, and see that on all these transactions we have only £256. 10s. of outstanding arrears, you will agree with me that the result is that the whole business has been transacted in a satisfactory manner. These arrears are being collected in due course, and they will very shortly disappear from the balance-sheet. Now I come to the Debenture issue. The Debentures of £75,000 which the new Company has issued could, of course, be issued only with the consent of the existing Debenture holders of the old Brush Company. We had to get them to consent; that is to say, we had to get them to convert their Debentures for new Debentures, or else we had to pay them off. The long and short of it was that they met us in a friendly spirit; they had perfect confidence in the value of the property, and I may say that the charge on these great properties is very light indeed. And all the Debenture holders agreed to take the new Debentures for the old, with the exception of £7,900, and that amount of Debentures had to be purchased by the liquidators of the old Company, and they are still in our hands, forming a valuable security for any shareholder who likes to get 6 per cent. for his money. It is a valuable security, and applications to the Secretary will meet with response. I think it is very desirable to keep these Debentures amongst ourselves for reasons which I need not go into, because they are perfectly obvious; and I strongly urge the shareholders of this Company to absorb that £7,900 of Debentures. We will retain them in our hands for that purpose. There is no difficulty in disposing of them, and there are plenty of brokers in the City asking for them already. I should like to say a few words on the general efficiency of the combined works we now possess. The Brush Works in the Belvedere-road are very perfect, and the Falcon Works by themselves for the class of work they turn out are extremely satisfactory; but the combination of the two for carrying on the electrical engineering business as we do now, places us in an unrivalled position. The situation of these Falcon Works is everything that could be desired. It is just far enough out of London, in the Midlands, to enable us to obtain the best, cheapest, and most skilled labour, together with the cheapest fuel; and in addition to that it is on one of the main lines of railway, one of the great arteries of the country, and we have the Loughborough station at our doors, with sidings actually into our works. So I think from every point of view the Falcon Works are an eminently satisfactory purchase. As I have said before, taken in conjunction with the Lambeth Works, they will enable us to distribute our heavy and light works—our light, fine work, of which we do a great deal—we can manufacture them more satisfactorily, I think, in these shops that we have in the Belvedere-road. The heavy castings and larger class of work and machinery no doubt we can make to very great advantage, as I may explain later, at the Falcon Works as compared with what we could do elsewhere. These Falcon Works contain, briefly, about seven acres of freehold land. It is many times bigger than the works we have in the Belvedere-road. Roughly speaking, about two-thirds of the space is built over with old shops, which existed before we took over the works, and those we have built subsequently for about £20,000. I think it would be highly satisfactory to any shareholder who takes an interest in these things, if he can find time and opportunity to go down, to go and look at these things for himself. The opinion he will carry away will be eminently satisfactory, and he will come to the conclusion that the purchase is a wise one. I have already said that it places us in a position in conjunction with the Belvedere works to manufacture for ourselves, and to take the immediate profits on a class of work we were not able to manufacture before. The lifting power provided at these new works is very full, as it must be for the heavy class of machines we are turning out now. I should now like to say a few words with reference to the expenses to which we have been put and to the profits which we have earned. The profits that we have earned appear in the balance-sheet, and you can judge for yourselves. As regards the charges for expenses, I know that shareholders when they get a balance-sheet of this description, although it is the first, and cannot fairly be compared with reports and balance-sheets of the Brush Company that have preceded it, involuntarily contrast the figures and see how they compare with the standing charges of the previously existing company, of which they were shareholders. You will find that the standing charges have undoubtedly slightly increased, and I am bound to say it could not be otherwise, when you consider the vast body of work we have done, the expenses of amalgamation and the expenses of having to run these additional works. The Brush standing charges of 1888 were £11,131, and those for the past year amounted to about £16,000. I do not know that I can hold out very much hope of these standing charges being much reduced in the uture. Of course, we shall do what we can, but I am bound to say that I do not hope they will be much reduced in the future. Our business is increasing daily, and if it continues to increase the general charges must

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increase also. This is from no want of care; it is one of the inseparable results of increasing business. Then as regards the liquidators' balances and suspense accounts which figure for the small sum of £9,979, I think you may make your mind quite easy on that score. There is no less than £7,900 of the £9,900 represented by the Debentures of the old Brush Company, which the liquidators have purchased and hold ready for issue when any demand arises. Then the balance consists of sundry small debts and accounts, so that there is no reason for any feeling of uneasiness in your minds at the sight of that entry in your balance-sheet. Then, there is one other matter which I must allude to—a matter that used to be always before our minds when we simply represented the Brush—and that is litigation. We have pretty well washed our hands of litigation, as you all know, and I think we are all thankful for it. The only remnant is a thing called the King-Brown lawsuit. That, by-the-bye, was a compound-winding action. It was tried in the English Courts, and the decision given in our favour; our patents were upheld, and the result was that every manufacturer in England agreed to pay us tribute on every compound-wound machine. Well, a firm in Edinburgh thought it was worth while to try this case in the Scotch Courts. The Scotch Courts have been known to take a different view from the English Courts, especially in patent cases; and the case was tried in the Edinburgh Courts by those people, King-Brown, who are not very large makers. After a lengthy but not very costly litigation it was decided against us. We naturally appealed to the Court of Session, and we lost the appeal. We then notified our intention of taking it to the highest court of appeal in the Kingdom, the House of Lords, which we are enabled to do. It will not involve a very great expense. I say we were bound to bring it before the House of Lords for two reasons: first, because the English Courts had given it in our favour years ago; and, secondly, to justify our position in having charged and received these royalties from every maker in Great Britain for some years for every compound machine turned out in their shops. That is the last bit of litigation we had when we used to meet as members of the Brush Company. That will be wiped out, I suppose, shortly after the House of Lords meets. It is impossible to say what the decision may be. The House of Lords may decide to uphold the finding of the English Courts, or it may decide to uphold the Scotch Courts. If we gain, we shall continue a valuable source of revenue as royalty from these machines. Now I should like to mention the policy we have pursued in regard to a matter of importance, certainly, I think, second to none in electrical work, and that is with regard to obtaining Provisional Orders. You know the Board of Trade grant Provisional Orders, which have to be confirmed by Parliament. Well, you know that all these electrical companies who are competitors, have largely applied for these Provisional Orders, and we should have been left out in the cold if we had not done the same thing. But we have, as a general rule, confined our applications to places we had interests to support; for instance, such as Bournemouth and Cardiff, and places of that sort, where we had large interests involved; and we have as a result of these applications already acquired, as you know, the Bournemouth order; and we have acquired, which is no trifling matter, one-third of the City lighting. The City has been divided into three great districts. We have acquired the central one, which is certainly not second in importance to any of the others. The magnitude of that Provisional Order is great; but we have to carry it out under very favourable conditions, under strict terms as to dates, but still not at all impossible terms. We have, for instance, some months before us before we are compelled to commence work. After that the work has to be executed with reasonable delays, but with a lapse of time which I have no doubt will enable us to satisfactorily meet all the requirements of the case. The cost of carrying out the Provisional Order will, I suppose, amount to something like £300,000. That is a very large item of business. Of course, we do not suppose that we are going to do all that business for nothing. We think it a very valuable asset indeed, and we intend to proceed with it with all the care we can command. We have on our Board and in our offices most experienced men dealing with electrical and engineering work—the engineering work is almost as important as the electrical work—and they combine to the fullest extent the knowledge and experience of both branches of the business. We shall spare no time or labour, or, in fact anything, to carry out the Provisional Order in such a way as will redound to the credit of this Company, and also be productive, I venture to anticipate, of very considerable profit. I think I have very little more to say. I have, perhaps, spoken already at greater length than I had any business to do, but really I could enlarge upon a great many points for an almost unlimited time. I think, however, the most satisfactory plan would be to leave you to put any questions that you like on any particular points that may occur to you on which I have not given you such information as you might desire. I think I will only now, with your permission, before moving the adoption of the report and balance-sheet, say a few words about the dividend and the accounts. Well, you see the profit and loss account shows a gross profit of £36,698, and after deducting all standing charges, maintenance of plant and buildings, and interest on Debentures, there remains a balance of £14,235. Out of that it is proposed to apply £625 to reduction of preliminary expenses, £500 to reduction of Provisional Orders account, and £3,000 to reduction of property, patents, and goodwill account, to meet depreciation under these heads. I think you will find that will leave a balance of £10,426 to appropriate. Of course, out of that has to come the interest due on the Preference shares for the six months from February 10th last up to the present time. That comes to £3,505. We propose then to pay the dividend on the Preference shares, and to carry forward, after writing off the sums I have already mentioned a balance of £2,796 to our next account. But though we have chosen to recommend the writing off of certain amounts, I hardly think myself that it is necessary. For instance, we are writing off £500 on account of the Provisional Orders. And you might not think it necessary to write off £3,000 from our property account. You might not think it necessary to write off in the first year a proportion of our preliminary expenses, which only amounted to about £1,800. We propose, however, to write off one-third of that amount this year. It is no doubt very proper to write off these sums—and I hope you will agree to our recommendations—but you are not compelled to do so, and you will find in that event £6,800 available for dividend on your ordinary shares. That would represent a dividend on only 11 months' working of 3 per cent., after paying the fixed dividend on the Preference shares, the Debenture charges, and other legitimate charges, and without taking into consideration any profits accruing from the Australasian Company. I say that is not a very bad show for the first year of these three amalgamated companies. It is possibly within the recollection of some of you that when I stood here at this time last year I said that I should not have the courage to come before you again, unless we found ourselves in the satisfactory position which I prophesied. Well, I venture to hope that you will regard that pledge as being practically fulfilled. The dividend is there if you like to take it, but we do not recommend you to take it. We would rather you appropriated it in the way suggested in the balance-sheet. We feel sure it is necessary for us to occupy in the future a strong financial position as well as a strong manufacturing position; and nobody can occupy a strong financial position in this City of London unless they act on certain well-known and recognised rules. One of these recognised rules is to write off from your patents and property account as much as you can afford every year, and also a portion of other charges which may be of an exceptional character. I say, then, that the lines on which this balance-sheet has been drawn out and approved by our auditors and on which the appropriation scheme has been framed, is one of sound finance, and I think you will do very wisely in accepting it. There is another reason of the first importance why we should occupy a strong financial position. We have this big City contract, with £300,000 looming in the distance. I do not say we have to raise £300,000. Nothing of the kind. The £300,000 that we have to do work to the extent of will be provided for in our shops in the usual way. We shall receive payments on account in proportion as the work may progress; but undoubtedly you cannot enter upon the carrying out of a contract of these dimensions without a certain amount of ready money in hand. Although we have now fair cash balances, a large amount on deposit, and a large amount due to us from trade creditors, and everything in the most satisfactory shape, yet such a large contract as I have mentioned will very probably require some provision to be made for some extra financial assistance of a temporary or permanent character. At least, that is my opinion to-day. I do not mean to say that it is absolutely necessary, or that it will be so; but at any rate you need not be surprised if we have to come before the shareholders or the public or the Debenture holders for further money for the legitimate purposes of business. And, if such an event should occur, it is necessary, of course, that our last balance-sheet, which will be critically examined, should be a thoroughly sound and conservative document. For these reasons I hope you will see your way to accede to the appropriation scheme we have drawn out in the balance-sheet for the past year. The adoption of the report and balance-sheet will be seconded by Mr. Van Tromp, who was the Chairman of the Australasian Company which we have absorbed, and I think he will be able to tell you a great many interesting things connected with this Company. I will therefore not detain you any longer, but beg to move:—

"*That the report of the Directors and statement of account to June 30th last, now presented to the shareholders, be received, and that the same be hereby adopted*" (applause).

Mr. H. B. VAN TROMP seconded the motion, and said that had it not been for the invitation of the Chairman, he would not have desired to address the shareholders that day; but since the Chairman had asked him to speak he would offer just a few remarks, and on his own behalf and that of the other members of the Board, he could give the shareholders this assurance that, so far as they knew, the Company was on the high road to prosperity (applause), and that there was a great prospect of success, and there could be no doubt whatever that when they met at this time next year they would have a far better position of things to place before the shareholders than they did that day.

A VOICE: I hope so.

Mr. VAN TROMP, continuing, said that he had seen the works at Loughborough, and he did not hesitate to say that, for the purpose for which they were destined, there were very few better works in all England. They possessed appliances there which would enable them to do everything in connection with the utilisation of electricity as a motive power in the future. They could turn out anything there, from a common piece of electrical apparatus to a large locomotive or car. They could make anything that they liked. There was nothing in the whole world connected with railway traction that they could not manufacture at Loughborough, and with greater economy. He (the speaker), as they knew, was the late Chairman of the Australasian Company, and when that business was taken over by the Brush Company, it took over, which the noble Chairman had omitted to mention, the patents for the Cape of Good Hope and India. He (the speaker) looked upon India as the future great field for electric lighting. It was a country of luxury and wealth, full of very rich people and princes with enormous incomes. It was a very warm climate, and, therefore, the advantages of the electric light, as compared with gas, were very great. It was a field that he felt could be very largely developed with most beneficial results (applause). Their noble Chairman, probably in his desire not to say too much, had omitted any reference to the Company's business abroad—in Vienna and Austro-Hungary. It would be seen from the report that they were doing very well indeed at Vienna, and that they had already earned a considerable profit on the very small capital that had been spent there. They looked forward to continued success in this direction, and also to

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still more satisfactory results in the future. As to Austro-Hungary, it was one of the very few places where electricity was actually beating gas on its own ground. The time might come when they would find these gasworks shut up altogether. He did not know that he had much more to tell the shareholders; he assured them on his own behalf and that of his colleagues, that they would do all in their power to make the Company a great success. Shareholders were generally satisfied when they received a good and regular dividend, even though the concern might very well have paid more than they received. Well, the Directors of this Company would not be content with giving the shareholders a good dividend, but would strive to pay them a very handsome dividend. He had much pleasure in seconding the resolution.

The CHAIRMAN invited discussion.

Mr. SMART felt that the Directors should be made acquainted with the feeling of the shareholders with regard to the non-receipt of any dividend for so many years past, and there were feelings of very great disappointment. It had always been much the same story—they were always being fed with promises for the future. This had been what they had to accept year after year; and as a shareholder of many years' standing, he could only express a feeling of very great disappointment at hearing the same remarks year after year. The Chairman had remarked in his speech that they could not very well expect a dividend this year, inasmuch that it was the first annual meeting after the registration of the Company.

The CHAIRMAN: I beg your pardon, the shareholders are getting a dividend this time.

A VOICE: Not the ordinary.

Mr. SMART, continuing, said that the Preference shareholders were getting their dividend; but as all the shareholders held both ordinary as well as Preference shares, it only made a dividend of something like 2 per cent. for the last 12 months. He thought that 2 per cent. was a very poor dividend for five years.

The CHAIRMAN: It is 6 per cent. per annum upon the Preference shares.

Mr. SMART said he would be very glad to know if there was any possibility of the ordinary shareholders being soon in the receipt of dividend. He felt very dissatisfied and disappointed, and that was the reason he had risen and given vent to these observations.

Mr. WARD referred to the large amount of salaries, £8,088; he thought it a very great deal, and would like some explanation upon the point. There was another matter to which he wished to also refer. He was very largely interested in tramways, and he looked forward to the time when tramways would be propelled by electricity. It, however, seemed to be a case of hope deferred, all the attempts that had been made in this direction up to the present time having been failures from a financial point of view. He would like to know from the Chairman whether it was probable that this Company would be able to run tramways by electricity successfully and profitably. He felt confident that any Company that could successfully solve this problem would have a wonderful future before it. He would be glad to have some information on the subject. Now, as to the question that had been raised by the previous speaker with reference to the dividend on the ordinary shares, he had to confess that at any rate the Preference shareholder had no cause of complaint, for he had got all that he could expect, viz., his 6 per cent. He himself held a larger number of ordinary than of Preference Shares, and he would very gladly look forward to the time when the ordinary shares would be in receipt of a dividend, but he did not think that it was fair on the present occasion to press the Board too closely on that question. He certainly hoped that when they met at that time next year the Directors would be able to declare a dividend on the ordinary shares, and he should look very closely into the accounts then presented.

Mr. WILLIAM BROWN referred to the fact that he was a shareholder riginally in the Australasian Company, and he wished to know upon what principle the shares were divided. It was true that he was only a small holder in the previous Company, having only £25 invested, but for that £25 he had only received under the amalgamation one Deferred share. He understood that the Preference and ordinary shares were to have been divided in equal proportions, and he wished to ask whether some people had had the pick of the Preference shares and others had had to be contented with the Deferred shares.

Mr. B. H. TROMP (late Chairman Australasian Electric Light and Power Company, Limited) answered the question and said that he could assure Mr. Brown that the shares had been equitably divided, and that whatever that gentleman had been entitled to he had received. He must bear in mind that £25 was a very small proportion of the capital of the Company, which was £160,000, or if they included the Edison shares £200,000. A circular was issued containing a schedule from which Mr. Brown would have seen that he had received what he was duly entitled to; but if he was still dissatisfied he (the speaker) would be happy to give him the fullest possible information as to the manner in which the whole of the shares were divided, and he assured him that he would find such information to coincide with what he (the speaker) was now stating.

Mr. WILLIAM BROWN said that he understood that he was to have received both Preference and ordinary shares, but he had not received any Preference.

The Rev. Mr. STOBART said that he also received the circular to which Mr. Van Tromp had alluded, and he considered it somewhat misleading. He was a holder of 50 shares in the old Company, and therefore he made out that he was entitled to receive two shares in the new Company, and he was exceedingly surprised to find that he got eight Preference and nine ordinary shares, or four times as many as he expected; he therefore had no reason to complain (laughter and hear, hear).

After some further discussion on the same subject, Mr. VAN TROMP said that he would write a letter to Mr. Brown, giving him all the information on the subject that he desired.

The CHAIRMAN, in reply to the various questions, said he agreed with Mr. Smart that it would have been more satisfactory if the Directors had had a large dividend to give to the ordinary shareholders on this occasion. He for one should have profited by it, as he had three-fifths of his holding in ordinary shares. But they could not expect everything at once. They knew the very great difficulties that had beset the electrical industry for all these years; but owing to various things—for instance, the last Act of Parliament removing the restrictions, which were quite prohibitive, and the public demand for the electric light—he thought they might be pretty sure that the time had come for reaping their harvest in the future. They had an indication of that in what they had already earned. So if they considered the advantageous position they now occupied, he thought they would agree with him that they were entitled to have very sanguine hope of the future. He hoped that in the future, as one speaker had remarked, they would have not only a good but a handsome dividend. With reference to electrical tramcars, this business had been beset with difficulties of various kinds—legislative and otherwise; but it was emerging now from these difficulties, and that was another of the obvious reasons why they amalgamated with the Falcon Works, which were so admirably adapted for the manufacture of electric tram cars. And moreover it got them into communication and actual touch with the people who were now using horse cars. There was a large number of horse cars turned out at the present moment from those works. Only the other day they received an order from the London Road Car Company for 60 new 'buses. That brought them into touch with the people who had control of the tramway interests in this country; and it stood to reason that when they adopted, as they undoubtedly would, these electric tramway cars this Company would come in for a fair share of the orders. This was a matter they had considered for years. They had made numerous experiments in their Belvedere works, and they were following them up; and whenever business came he felt sure they would get their share of it.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
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BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
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In the same way with electric launches. They were making a great many marine engines at the present moment, and the class of work they were executing now was so varied, and altogether opened up so many new avenues of future business, that he could not help having a sanguine view of their future from a pecuniary point of view.

The resolution was then put and carried.

The CHAIRMAN then proposed that the dividend as recommended be declared on the Preference shares.

The motion was seconded and carried.

The Auditors, Messrs. Cooper Bros. and Co., were re-elected, and a vote of thanks to the Chairman and Directors closed a lengthy meeting.

The Aluminium Company (Limited).

The third annual ordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel, on the 9th inst., when Mr. G. W. BALFOUR, M.P., presided, and in referring to the result of the past year's operations, he expressed the regret that he felt, and that was shared by his colleagues, at their unfortunate position. Still, it was a result for which the Directors took no blame to themselves. At the time when the Company was floated aluminium was a very expensive metal, something like 50s. to 70s. per lb., and they had hoped to have been able by their processes to have produced and sold it for 20s. per lb.; and if the hopes that had been entertained had been fulfilled, there was no doubt that they would have achieved a very great success. They were aware of the electrical processes to which the following paragraph in the report referred:—"But in the course of the past twelve months, by the introduction and successful working of electrical processes, a further very large reduction in price has taken place, until at the present moment the market price of pure aluminium stands at from 6s. to 8s. per pound." These electrical processes, up to the time of the formation of the Company had not proved a success, and therefore the Directors could not be blamed for not having foreseen subsequent events. Electrical processes, it was true, had produced alloys of aluminium, but not the pure article; and they at the time believed that it was impossible to produce a pure aluminium by the electrical process; but they were deceived, and they had been deceived in common with scientific experts, and therefore they could not be expected to foresee what the scientists could not foresee. With the success of the electrical processes their position became a very serious one, and they had to consider what was to be done. Had it not been for the other patents they would probably have had to adopt the course of calling the shareholders together and considering the question of liquidation; but, of course, that would mean a certain amount of loss. Well, Mr. Costner, their chemical engineer, set to work to develop these other patents belonging to the Company, with a whole-hearted energy in the interests of the Company that laid him up from overwork. The result was that the perfection of the new process was delayed, and they did not overcome the whole of the difficulties till the month of August; but they were now, he was glad to say, in possession of a method for the manufacture of aluminium, which, after the Directors and their experts had gone fully into the matter, convinced them that they would be able to compete in price with the aluminium which was produced under the electrical process. As far as he personally could judge, the new process as against electricity would be a complete success. They had a similar testimony from Sir Henry Roscoe, one of their Directors, and their expert in the matter, and they had arrived at the conclusion that the perfected new process would once more place them in a position to compete with the electrical process. Having dealt with various items of accounts, he concluded by moving the adoption of the report.

Sir HENRY E. ROSCOE seconded, and stated that no one could have foreseen that the electrical process would develope into the great success that it had done. He expressed his confidence in the success of the new process as a competitor to the electrical process, and in the future of the Company.

Mr. C. W. WOODS maintained that the Directors should have more fully inquired into the value of the process which they purchased, and which had subsequently been superseded.

Mr. BROOKIE asked the Chairman whether the Directors were aware that the process they bought and floated the Company upon was condemned by other people beforehand.

The CHAIRMAN, in reply, said that as to Mr. Brookie's statement the Directors were unaware that the Costner process was condemned by anyone. If it had been he felt that it could only have been condemned by a competitor.

The report was ultimately adopted unanimously.

NEW COMPANIES REGISTERED.

THE FREEDMAN BATTERY COMPANY (LIMITED).—Registered by William Webb and Co., 6, Essex-street, Strand, W.C., with a capital of £2,000 in £1 shares: To acquire an electrical battery, particulars of which are not detailed, in accordance with an agreement made with Charles H. Freedman. The first Directors are Edward F. Wyman, Charles H. Freedman, and T. F. B. Evans. Qualification not specified. Remuneration to be determined in general meeting after declaration of 10 per cent. dividend.

THE RAILWAY CONSTRUCTION AND MAINTENANCE COMPANY OF MEXICO (LIMITED).—Registered by Bircham and Co., 50 Old Broad-street, E.C., with a capital of £100,000 in £10 shares. Object: To construct, execute, repair, maintain, and work any railways or tramways, roads, canals, watercourses, warehouses, factories, harbours, docks, piers, wharfs, sewers, waterworks, gas, electric and other lighting works, and to solicit, apply for and obtain, either in the name of the company or of third parties or companies, concessions, subsidies, decrees, Acts of Parliament or other authorities for or in connection with the construction, working or maintenance thereof; to deepen any harbours, rivers, or channels, and to execute any other public works in the Republic of Mexico or elsewhere, and to carry on and do all such other businesses and things as are usually carried on or done by contractors for public works, builders, or engineers.

CITY NOTES, &c

AMERICAN BELL TELEPHONE COMPANY.—This Company has declared a quarterly dividend of 3 per cent., payable October 15th.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 5th amounted to £5,821.

COMMERCIAL CABLE COMPANY.—The transfer books of this Company will be closed from September 20th to October 2nd, for the payment of the usual quarterly dividend of 1½ per cent. on October 1st.

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY.—We learn that the prospectus of this Company, which has been formed to acquire the patents for France, will be issued to the public in a few days. The capital is to be, we understand, £200,000 in 100,000 shares of £2 each, of which it is intimated that 66,700 will be offered for subscription at a premium of 10s. per share.

MUNTZ'S METAL COMPANY.—The Directors have declared a half-yearly interim dividend at the rate of 5 per cent. per annum on the original and Preference shares.

PILSEN-JOEL AND GENERAL ELECTRIC LIGHT COMPANY, LIMITED (IN LIQUIDATION).—A meeting of shareholders in this Company was held on Friday, at 18, Laurence Pountney-hill, Cannon-street, to receive the liquidator's report; but the representatives of the Press were refused admission.

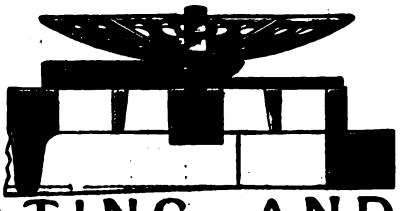
STOCK EXCHANGE.—The committee have ordered the following security to be quoted in the official list:—National Telephone Company (Limited)—2,284 additional shares, Nos. 436,701 to 438,984.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 5, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,590.

WESTERN UNION TELEGRAPH COMPANY.—This Company has declared a dividend of 1¼ per cent., payable October 15th.

NEW VALVE

No Rubber, Percha, or Leather.



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Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 29th Sept. 1886.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

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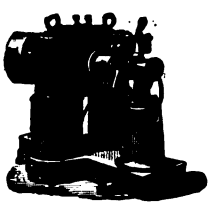
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 3.		Price Wednesday, Sept. 10.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 10.	
£			**TELEGRAPHS.**					£ s. d.		Highest.	Lowest.
1,381,380	Stock	15/0	Anglo-American	51	52	51⅛	52⅛	5 4 9	Jan., Apr., July, Oct	51⅞	51
2,809,310	Stock	30/0	Do. Preferred	87⅛	88⅛	87⅛	88⅛	6 4 4	" "	88⅜	87⅜
2,989,310	Stock	..	Do. Deferred	15⅛	15⅞	15⅛	15⅝	..	.. ..	15⅛	15⅛
25,000	£100	4%	African Direct, 4 per Cent. Debentures	97	100	97	100	4 0 0	January and July	..	..
130,000	10	3/0	Brazilian Submarine	11⅞	12⅛	11⅞	12⅛	5 6 1	Mar., June, Oct., Dec.	12	11⅞
69,200	100	5%	Do. 5 per Cent. Bonds	100	102	100	102	4 18 0	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	..	..
$7,216,000	$100	..	Commercial Cables	103	105	103	105	..	..	104⅛	103⅛
£16,000	£10	8/0	Cuba Submarine xd	12⅛	13	12½	13	6 10 9	February and August	12⅞	12½
6,000	10	10%	Do. Preference 10% xd	16½	17½	16½	17½	5 14 3	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3⅜	4	3½	4⅛	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10½	10⅝	6 13 4	Jan., Apr., July, Oct.	10⅝	10⅝
400,000	10	5/6	Eastern	13⅜	14⅛	13⅜	14⅛	4 12 0	" "	14⅛	13⅞
70,000	10	6%	Do. 6 per Cent. Preference	15	15⅛	15	15⅛	3 17 5	" "	15⅛	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	105	103	105	108	3 14 1	May and November	..	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14	14⅛	14	14⅛	4 18 3	Jan., Apr., July, Oct.	14⅜	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Aust'n. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	100	103	102	105	4 15 3	" "	102⅛	..
180,227	10	4/3	Globe Telegraph and Trust	8⅞	9⅛	8⅞	9	5 11 1	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15	14⅜	15	4 0 0	" "	15	14⅜
150,000	10	5/0	Great Northern	15⅜	16⅛	15⅜	16⅛	4 12 4	Jan., April, and July	16⅛	15⅜
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100	103	100	103	4 17 1	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	37	39	36	38	6 11 7	April and October	..	..
33,348	10	4/0	London Platino-Brazilian	6⅛	7⅛	6½	7⅛	5 6 8	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures xd	105	108	105	108	5 11 1	March & September	..	..
9,000	8	6/0	Reuter's	7⅜	8⅛	8	8⅛	5 19 4	April and October	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	113	117	113	117	5 2 7	" "	116	115
15,609	£10	6/6	West African	9	10	9	10	5 0 0	.. ..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures xd	99	102	99	102	4 18 0	March & September	..	..
30,000	10	3/0	West Coast of America	3⅛	4⅛	4⅛	5	10 0 0	January and July	5⅛	4⅞
150,000	100	8%	Do. Debentures 8%	101	106	101	106	7 10 11	June and December	103	102
88,321	10	Nil.	West India and Panama	2⅞	3⅛	3	3⅛	..	..	3⅛	2⅞
34,563	10	6/0	Do. 1st Preference 6%	11⅛	12	11⅛	12	5 0 0	April and October	11⅞	11⅛
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	13	14	13⅛	14	4 5 9	.. ..	13	..
64,572	15	6/0	Western and Brazilian	11	11⅛	11	11⅛	5 5 3	May and November	11⅜	11⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅞	7	6⅞	7	..	..	6⅞	..
26,986	7½	4/6	Do. 5 per Cent. Deferred	4⅛	5	4⅛	5	..	..	4⅛	4⅛
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103	106	103	106	5 13 2	.. ..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101	104	101	104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	120	125	5 12 0	May and November	..	..
£175,100	£100	6%	Do. 6 per Cent. Sterling Bonds xd	97	99	97	99	6 1 3	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5⅝	Consolidated Telephone Const. and Maintenance	⅝	1⅛	⅝	1⅛	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	½	⅝	½	⅝	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅜	4⅞	4⅜	4⅞	6 6 4	June and December	4⅞	4⅜
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12	12⅜	12	12⅜	4 16 0	June and December	12⅜	12⅜
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10	10⅜	10	10⅜	5 14 3	" "	..	..
209,750	1	½%	South of England, Ordinary	⅜	⅝	⅜	⅝	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd).	2⅝	3	2⅝	3	..	..	..	..
55,000	5	1/0	United River Plate	3⅜	4	3⅜	4	..	January and July	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	.. ..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	1⅞	2⅛	2⅛	2⅛	..	.. ..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4	4⅛	4	4⅛	..	.. ..	..	..
42,853	5	..	Westminster Electric Supply	1⅛	1⅜	1⅛	1⅜	..	.. ..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1⅞	2	1⅞	2	..	.. ..	..	..
63,416	2	1/2	Do. Preference	1⅞	2	1⅞	2	..	.. ..	..	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5⅛	5⅜	5⅛	5⅜	..	.. ..	..	..
353,478	5	..	Edison and Swan United	..		..		..	.. ..	..	..
409,000	10	..	Electric Construction	7⅜	8⅛	7⅜	8⅛	..	.. ..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	7⅛	7⅜	7⅛	8⅛	..	.. ..	7⅛	..
20,000	5	..	Fowler-Waring Cables	2	2⅛	2	2⅛	..	.. ..	8⅛	7⅜
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	17⅛	18⅛	18	19	5 5 3	February & August	..	..
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	.. ..	18⅛	18⅛
78,949	5	6%	Swan United (£3. 10s. paid)	5	5⅛	5	5⅛	3 16 5	.. ..	..	..
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	5⅛	5⅛
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100	102	100	102	4 18 0	..	43⅛	42⅛
										101⅛	..



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(Statter's) WRITE FOR THE FOLLOWING PAMPHLETS TO THE (United)

ELECTRICAL ENGINEERING CORPORATION, Ld.

PLANT WORKS: WEST DRAYTON, near LONDON.
FITTINGS WORKS: ALBERT WORKS, 36, ALBERT EMBANKMENT, S.E.
LONDON OFFICES: 3, PRINCES MANSIONS, VICTORIA STREET, WESTMINSTER.

"ELECTRICAL DISTRIBUTION."—Commercially considered, with Estimates.
"MACHINE DRIVING BY ELECTRICITY."—The Uses of Electro-Motors for Traction and Stationary Purposes.
"THE TELPHER SYSTEM OF CHEAP TRANSPORT," for Minerals, Goods and Passengers.
"ELECTRICAL SUPPLIES."—Prices and Particulars of the most approved Electrical Appliances

ELECTRICAL PLANT ON VIEW.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 644.—Vol. XXV. FRIDAY, SEPTEMBER 19, 1890. Price Fourpence.

NOTES.

The very conveniently-arranged "voltapile," which was exhibited at the British Association by Sir William Thomson, is an elaborate form of the device which has been used in more than one laboratory. The generation of several hundred volts in this simple manner suggests that there is still room for a portable battery for providing a small current at high pressure for testing the insulation resistance of house wiring, &c. A continuous current would be more likely, we believe, to discover leaks than an alternating one. Insulation tests with two or three Leclanché cells and a detector are almost things of the past; but we do not think that a magneto giving, say, a hundred volts, is a sufficient test for the best and most important work. It may be pleaded that for wiring for alternate-current supply an alternate-current test should suffice, even if a continuous pressure of four or five hundred volts might break down an incipient leak. If this be granted, we still maintain that the testing pressure should be at least double that of the working pressure.

It is difficult, if not impossible, with our present knowledge to define a factor of safety, as in boiler-making or in other branches of engineering construction, since we rarely inquire at what pressure a given insulation may be expected to break down. But it must be remembered that in London, at all events, many hundreds of houses that were wired for alternate-current supply have gone over to direct current, either from the rearrangement and definition of districts of supply, when alternating currents have become no longer available, or from choice on the part of the consumer. But apart from this, anyone doing the best work will not object to a reasonably severe examination; and it appears that the application of four or five hundred volts by means of such a battery as that which was described by Sir William Thomson, charged with an acid solution, so that an appreciable current may be passed, would not be too stringent a test. If an equally portable dynamo could be constructed, it would in some respects be more convenient; but we doubt whether a satisfactory machine could be made which could really be easily carried about, and it would certainly be considerably more expensive than a battery.

Some troublesome polarisation effects have recently been experienced in the working of the Commercial Company's cables at Coney Island, New York. They have been caused by the passage of heavy currents through an electric traction circuit about half a mile away, and running nearly parallel with the cable for about five miles. Mr. Cuttriss, Electrician to the Company, has succeeded in showing that the ground at considerable distances from the railway lead was subject to variations in potential amounting to as much as 4·3 volts; and when the electrostatic capacity of the cable sheath and the delicacy of the receiving instruments are taken into consideration, it does not appear surprising that the earth currents set up between the rails and the sheath were sufficient at times to render signalling impossible. It will, fortunately, not often be necessary to lay the land end of an ocean cable for several miles in the neighbourhood of a conductor carrying heavy fluctuating currents; but when the need arises it may be advantageous to surround the part of the cable in question with a more perfectly conducting sheath, connected at one end with the earth terminals of the testing instrument, and at the other with the ordinary metallic sheath surrounding the part of the cable immersed in the sea. If the new sheath is long enough to prevent any appreciable action at the extremities, it will screen the interior conductor from the effect of potential variations outside, in the same way as Faraday's metallic cage shields the interior from the action of external electrified bodies.

In another column we reproduce a short but interesting Paper by Dr. Sheldon, who has succeeded in directly converting part of the energy of a beam of light into the energy of an electric current. As is well known, if polarised light is passed along the axis of a solenoid, its plane is rotated by the action of a magnetising current passing through the coil, and the rotation is much increased if the core of the solenoid is formed of heavy glass or liquid bisulphide of carbon. If energy is required to produce the shifting of the plane it must be obtained from the current, so that a back electromotive force must be set up in the coil by the rotation. If this is true, it follows that by merely rotating the plane of polarisation an electro-motive force must arise in the coil whether a current flows through the latter or not. Dr. Sheldon has succeeded in detecting the effect by making use of the extreme delicacy of the telephone. The demonstration seems satisfactory, for it is hard to imagine how the result obtained could have been brought about by any other action than the one stated.

The process of reasoning used by Dr. Sheldon in estimating the voltage set up in the magnetising coil is unfortunately

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omitted, although, with the aid of some experimental results obtained by Mr. PREECE, it is easy to calculate it approximately. The current necessary to produce a perceptible sound in the telephone has been estimated by Mr. PREECE at something like 10^{-12} ampere (one million millionth of an ampere), and by multiplying this by 7 ohms, the resistance of the coil used in Dr. SHELDON'S experiments, we obtain an approximate estimate of the voltage. The number obtained is smaller than that given in the Paper; but this is probably due to the fact that the impedance of the coil, for such rapid alternations as were used, was considerably in excess of 7 ohms.

WE are glad to notice that with the approach of the stormy season the question of communication between lightships and the shore is again being discussed in the newspapers. All the arguments for and against the use of electricity in this connection were impartially set forth by the *Standard* a few days ago, with the unavoidable conclusion, as it seems to us, that nothing short of electrical cables, if capable of being permanently maintained, will meet all the requirements of the case. The experiment at the sunk lightship off Harwich proved costly and inadequate, but only because the cable, or its connection with the ship, frequently broke down. A perfect appliance has yet to be devised that will relieve the cable of the strain to which it is subjected by the shifting of the ship; but if this problem were solved, the Elder Brethren of Trinity House would probably be as strongly in favour of electrical communication as they are now opposed to it. At present they decline to incur the cost of an indefinite number of experiments like the one with the Harwich lightships; and we cannot blame them. It may be hoped, however, that proof will not long be wanting that a cable moored to a moving lightship may be made as trustworthy as one landed at a fixed point; and when this is done we are persuaded that the uses to which it will be put for signalling purposes, other than those relating to shipping disasters, will go a great way to repay the original outlay..

THE "magnetic brass" trouble to which we referred in our last issue is, as will be seen by Mr. SYDNEY EVERSHED'S letter this week, by no means confined to the humble compass case. A correspondent who has great experience in instrument making also writes:—"I have occasionally found a bit of *cast brass* slightly magnetic, but never *rolled*, to the best of my remembrance." The last paragraph of Mr. EVERSHED'S letter, however, shows that there is no safety even in rolled brass. There is, it would seem, room for a new patent non-magnetic brass, more amenable, it is to be hoped, to the tool than is the steel of that description.

THE recent letter from Mr. GLADSTONE to Sir ROBERT BALL, the Astronomer Royal of Ireland, raises the suggestion that we may find in the versatile ex-Premier the man who shall reorganise and firmly establish our system of electrical nomenclature. In the course of his omnivorous reading, Mr. GLADSTONE has studied Sir ROBERT BALL'S charming book "Starland," and he welcomes any knowledge which can be presented to him "in a form in which it makes a minimum demand upon a diminishing brain power." The enormous figures representing the distances of the fixed stars impressed Mr. GLADSTONE, as they do all readers of the subject; but he suggests that some symbols should be introduced which would simplify matters when vast quantities are introduced, which will convey more meaning than the rows of cyphers, or the verbal expressions of thousands of billions of miles. When Mr. GLADSTONE first became Chancellor of the Exchequer, he found that the Bank of England and the Treasury used the letter M as a conventional and convenient sign for £100. Mr. GLADSTONE improved upon this "by adopting M with a tail over the back for a million." The financial demands upon the Treasury rarely ran so high as the French milliard; but Mr. GLADSTONE daringly invented "M in a ring" as being equivalent to the milliard. "It occurs to me," writes Mr. GLADSTONE, "that symbols of this kind (replacing £ by miles) might be of some use, perhaps, in writing astronomical distances."

WE have already adopted **M** in magnetic work, and for the unit by which high vacua are measured; it is also used by some writers as a millionth of a millimetre in expressing the wave-length of a ray of light. It has a meaning of its own in kinematics; and, therefore, though it may be admirably adapted for astronomical work, we cannot accept it, nor indeed do we require a general symbol for a million or millionth. The symbols ω and Ω are sometimes used for ohm and megohm, although ω denotes angular velocity. Dr. OLIVER LODGE felt that the recent occasion on which he was invited to promulgate his "revolutionary views" on nomenclature at the British Association was not a suitable one, and he suggested another day for the debate, which eventually fell through. Symbols and nomenclature are closely allied. Who will lead us into battle?

WE understand that, owing to an advertisement issued by a responsible advertising agency in this country, some apprehension existed as to whether the tenders of a number of large English firms for the electric lighting of Stockholm would have been received in time. The original advertisement inviting tenders gave the time for their receipt as September 1st. This was subsequently extended to September 15th; and by the advertisement referred to above (which appeared in our issue of September 5th) this time was still further extended to October 12th. Several firms who had been working hard for some time upon the necessary details of this large contract found on inquiry at Stockholm that this last-mentioned extension was incorrect. The matter was then taken up by the London Chamber of Commerce, who succeeded in obtaining the valuable aid of the Foreign Office, and Mr. KENRIC MURRAY is now able to announce that an official telegram, received by him from Stockholm, states that tenders posted from this country not later than the 20th inst. will be considered. The issue of this misleading advertisement certainly requires explanation.

Scarborough.—Mr. Bernard Drake is preparing a report to the Corporation as to the course to be pursued by it having regard to the requirements of the Board of Trade Provisional Order.

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St. Pancras.—During the past week the site for the Central Lighting Station has been cleared, and building operations will be commenced in the course of a few days.

Glasgow and West of Scotland Technical College.—The autumn session of this College will shortly commence, and courses of instruction have been arranged in mechanical and electrical engineering, industrial chemistry, metallurgy, mathematics, physics, &c.

Dresden.—Messrs. Siemens and Halske will supply the plant for the municipal electric light station at Dresden. Accumulators capable of supplying 25,000 lights simultaneously will be put down. There are to be three engines of 450 horse-power each and three 320-kilowatt dynamos.

Proposed Canada-Florida Cable.—Sir Ambrose Shea, Governor of the Bahamas, has had a conference with Sir John Macdonald regarding the establishing of a line of steamships between Canada and the West Indies, calling at the Bahamas, and also the laying of a cable from Nassau Florida.

Salford.—The Salford Corporation are taking steps to establish a technical school under the Act of last year. The Town Council, at its last meeting, empowered its special committee to purchase a plot of land and the property on it adjoining the Peel Park Museum, on which to erect a technical school.

Berlin.—At 9.30 in the evening of September 3rd, during a representation of Shakespeare's "Tempest," the whole of the incandescent lights in the Schauspielhaus, Berlin, were suddenly extinguished. On an examination it was found that the leads have been broken away from the mains at both junction boxes in the Schillerplatz.

Destruction of the New Jersey Telephone Exchange.—During a thunderstorm on Wednesday the building occupied by the New York and New Jersey Telephone Company was struck by lightning and burnt to the ground. Some 2,000 telephone wires have been destroyed, and the damage is estimated at £25,000.

Church Lighting.—An electric light installation is being carried out at the church and Parochial Hall of St. John's the Divine, Vassal-road, Brixton. About 300 incandescent lamps will be used. The plant consists of a gas engine, a dynamo, and a set of accumulators. An electric motor is also being put down for blowing the organ.

Dublin.—On Friday last Mr. C. P. Cotton, C.E., Chief Engineering Inspector of the Local Government Board, held an inquiry in relation to an application by the Corporation of Dublin, for the sanction of the Board to the following amongst other loans:—A sum of £50,000 for the purpose of an installation for the supply of electricity.

Pemberton Local Board.—By way of experiment, the Local Board have accepted an offer from a firm of electricians to light about 400 yards of Ormskirk road with one arc lamp and six incandescent lamps for two calendar months, at a cost of £20; the Board also providing the engine power and poles, and labour to assist in the fixing of the poles and wires.

Royal College of Science, Dublin.—The first term of the 1890-91 Session of this College commences on the 6th October. The Royal College of Science supplies courses of instruction in the sciences applicable to the Industrial Arts. Four Royal scholarships of the value of £50 per annum are attached to the College. Further particulars will be found in our advertisement columns.

Obituary.—We regret to have to announce the death, at the age of 48, of Mr. T. Blaikie, the Secretary of the National Telephone Company, who succumbed to an attack of appolexy on Thursday last week. The deceased had been connected with the National and United Telephone Companies for the last eight years, having joined the staff of the latter Company at the beginning of 1882.

Brighton.—The Lighting Committee have decided to give notice to the Electric Construction Corporation that the Brighton Corporation will only require two sets of storage batteries, switch-boards, instruments and appliances, instead of four sets, as provided in the specification annexed to the contract; and that the contract sum will consequently be reduced from £5,242 to £2,700.

Charterhouse Science and Art Schools and Literary Institute.—The winter session of this, one of the largest Science and Art Schools in the United Kingdom, and a school which has trained some thousands of teachers for the offices of science lecturers, will commence on September 27th. During the late session about 900 students, mostly elementary teachers, availed themselves of the privileges afforded by this Institution.

Search Lights and Coast Defence.—Experiments are being made with search lights at various forts round the Isle of Wight. Nine or ten of the torpedo boats anchored in Totland Bay tried the other day to pass round the Needles under cover of the darkness. The search lights were used to prevent their progress, and fire was opened from the forts as soon as the lights revealed their whereabouts. Only one of the torpedo boats "escaped."

University College, Dundee.—The Engineering Department is in charge of Prof. Ewing. This College offers a complete course of instruction, comprising lectures and drawing office, field and laboratory work for students of civil and mechanical engineering. There is a large engineering laboratory, fitted with testing machine, experimental steam engine, &c., and also a special laboratory of electro-technology. The autumn session of this College opens on October 14th.

Spanish African Cables.—The Spanish Government has invited tenders for the supply and laying of submarine cables to connect Spain with the different Spanish possessions on the African coast. The lines to be first laid down are:—From Tarifa to Tangiers, 31 miles; from Tarifa to Ceuta, 22 miles; from Almeria to Alboran, 84 miles; from Alboran to Melilla, 53 miles; from Melilla to the Chafarinas Isles, 30 miles; from Melilla to Alhucemas, 84 miles; and from Alhucemas to Penon, 31 miles, making a total of about 335 miles. The maximum price offered by the Government is 4,000fr. per mile.

Finsbury "Special" Lectures.—The special courses of lectures at the City and Guilds Technical College, Finsbury, during the coming autumn are two in number. Prof. Silvanus Thompson takes a short course on "Electric Meters" on Monday evenings, and Prof. Perry will lecture till Christmas on "Valve-Gear." Mr. Halliday, the instructor in drawing, has arranged that there shall be two evenings set apart in the drawing-office in each week for instruction in electrical engineers' drawing, examples being taken from the most recent dynamo machines, motors, and lamps. The art studios of the College are now lit by electricity.

Bristol.—The results of inspections made by the Electric Lighting Committee of the Corporation, to which we referred in our last issue, have now been embodied in a long report from Mr. W. H. Preece and the sub committee of visitors. The report recommends that an installation should be established; and that the whole establishment should be in the hands of the Corporation. The number of gas lamps it is proposed to displace will be 170, their candle power is estimated at 5,920, and their cost at £1,131 14s. 7d. per annum. The sub-committee are informed that 50 arc lamps of 1,200 candle power each will be sufficient for the whole of the district they propose to light, and that the cost of each lamp will be about £25 per annum.

Electric Lighting in Australia.—At a recent meeting of the New Australian Electric Company in Melbourne, the Chairman stated that the lighting business was steadily increasing. The Company's new station near South Yarra was nearly completed, and would be ready for work in a month's time. The equipment of the station had been pronounced by English experts to be one of the most perfect yet constructed, being a duplicate of one of the latest and most approved stations erected in London. The capacity of that portion of the station nearly completed was equal to about 15,000 lamps; but the building had been so arranged that its extension could be carried on from time to time to meet all requirements. The mains are being rapidly laid throughout Richmond, Prahran and South Yarra; Government House, the Observatory and the Prahran Public Library being the first points to be served.

Chelsea.—Mr. T. W. E. Higgens, Surveyor to the Chelsea Vestry, states, in his annual report, that only one case of the absence of statutory pressure in electric mains has been brought

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to the notice of the Vestry. In this case, Mr. R. Chamberlain, M.P., of Cadogan-square, fixed a voltmeter in his own house, and found that on certain days the pressure had been below the limits permitted by the Board of Trade. This deficiency in pressure was probably owing to the fact that the Electric Light Company were at that time using temporarily a charging station at some distance from Cadogan-square. The Vestry left the matter in the hands of the Board of Trade, and no further complaint has since been received. There are in Chelsea about 139 houses now using the electric light, supplied as follows, viz. :—Chelsea Electricity Supply Company 113, Cadogan Electric Light Company 25, London Electric Supply Corporation 1.

A Differentially Wound Sprague Motor.—A differentially wound motor or generator, devised by Mr. F. J. Sprague and intended to avoid the difficulties due to distortion of the principal field by the field of the armature, has recently been described in the American technical journals. The method taken to accomplish this is as follows. The cross-magnetising effect of the armature produces an unsymmetrical field, and if the field produced by the regular magnetising coils be a symmetrical one, the result is sparking and other difficulties. Mr. Sprague attempts to counteract this by winding the field with unsymmetrical series coils, so that the distortion produced by the armature is in whole or in part counteracted by that produced by the series winding. To exactly what extent this ingenious device will accomplish the end in view remains to be seen. Whether the two cross-magnetising forces can be balanced so as to produce a uniform field can be proved only by experiment.

Gas Companies and Electric Lighting.—The following remarks in the last issue of the *Journal of Gas Lighting* may not be without interest to those who advocate the combination of the gas and electric lighting businesses. Gas companies, observes our contemporary, are not in any special way adapted for supplying the electric light or for the manufacture of lucifer matches; and they can no more powerfully urge a right to a monopoly of the one than they could of the other industry, supposing both to be subject to similar statutory regulations. There is nothing in gas plant, either manufacturing or distributing, that can be regarded as utilizable for an auxiliary electric lighting plant; and for a gas company to grasp at electric lighting as some foreign companies have done, is pure greediness of gain, which is invariably disappointed. There is no European gas company at this time making a profit by electric lighting; and if there are any in America, they have kept wonderfully quiet about it. It is to be hoped that no more will be heard of these petitions from British gas companies to be allowed to undertake electric lighting in the notices for the Gas Bills of next Session.

The Distribution of Lights in Textile Factories.—In our issue of August 15 we published a translation of a short article in *L'Electricien* on the distribution of arc lights in textile factories. In a recent number our contemporary gives the following extract from a letter of an engineer practically acquainted with the question of the distribution of light:—"In settling the height of arc lamps it is necessary to distinguish between outdoor lighting, such as that of railway stations and other open spaces where no work is being done, and open spaces where an intense light is required owing to the nature of the work which is being carried on. In the case of railway stations, yards, &c., the lamps should be very high. These are the heights at which we place them:—10 ampere arcs = 10 metres; 13 ampere arcs = 15–16 metres; 15 ampere arcs = 18 metres; 18 ampere arcs = 20 metres. When the spaces to be lighted up are used for some special purpose, such as wood-sawing, coal-screening, stone-cutting, &c., these heights may be reduced by 2 metres. With regard to globes, we find that large ones are preferable to small ones, since with the former the light has not the appearance of a sun-like disc. With large globes also the shadows of the illuminated objects are more broken up."

A Novel Telephonic Reaction.—We have recently, says the *Electrical World* of New York, had our attention called to an interesting phenomenon in connection with the telephone, which might be looked upon with suspicion by the uninitiated. While Messrs. Hibbard and Pickernell were conversing recently over one of the lines of the Long Distance Telephone Company, the former, in order to shut out some conversation, placed the receiver with the diaphragm end over the mouth-piece of the long-distance transmitter. The receivers at both ends at once began to give out a musical sound, which continued until the receiver was withdrawn from the mouth-piece of the transmitter. Investigation proved that the effect was due to an action similar to that employed in the well-known vibrating bell. An original impulse imparted to the transmitter is conveyed electrically through the primary and secondary circuits to the receiver, which, in turn, throws it back the transmitter through the intervening air, thus constituting a complete electric and acoustic cycle. This battledore and shuttlecock action between the receiver and transmitter is continuous as long as the receiver is held against the transmitter, and gives rise to a musical note of high pitch and great uniformity. Of course, it requires a powerful transmitter to produce the phenomenon, the ordinary Blake instrument being incapable of demonstrating it.

Bradford.—At the last meeting of the Town Council, Alderman F. Priestman proposed the adoption of the minutes of the Gas and Electricity Supply Committee, which included a resolution accepting the tender of Messrs. Siemens Bros. for the supply of machinery and cables required in the extension of the electricity works, for £450. Alderman Priestman said, with regard to the electricity works, that he had given a statement of the loss accrued to December 31st last; and he hoped to present a statement at the end of the present year. So far, the loss was short of £1,000. The electrical department had never been expected to pay in its earlier stages. An engine was now being laid down which would increase the output without augmenting the working cost; and he expected that in a few months the statement would be very much better than it would be if presented now. If the Council would appropriate a sum of say £10,000 from the profits of the Gas Department for the benefit of the electric lighting works, they could be made to pay their way. He hoped that ere long the Committee would be able to show that the electric lighting department was paying its way; but if not, it would be necessary to raise the price to the consumer. There was no cause to regret the steps taken in respect to this question. He had not the least doubt that if they had not taken the powers of supply themselves, they would have had to spend a great deal more money in keeping other people out. The minutes were then adopted.

A Chinese Telephone.—Our contemporary the *Engineer* is responsible for the following:—"A despatch from San Francisco states that the Bell Telephone Company is likely to have a persistent rival in a party of Chinese in that city whose ingenuity has enabled them to perfect an instrument which works remarkably well, and, it is asserted, is not an infringement on the Bell patents. The new instrument was brought to light through an investigation of the telephone company, which became suspicious of the increasing number of orders for the removal of the instruments from Chinese shops. For many months Wong Ching Wah, otherwise known as W. C. Young, a highly-educated and intelligent Chinese, has been engaged in electrical experiments, with a view to perfecting his smattering knowledge of the science obtained in an Eastern college. About a year ago he conceived the idea of attempting the construction of a telephone. From the electrical supply house in Mission-street he purchased the necessary parts of instruments; and a wood engraver in Kearney-street, under his Chinese customer's instructions, knocked together a box for the reception of the completed telephone. Wah screwed the parts together, and the result was so satisfactory that he straightway constructed a second similar instrument. This he set up in a neighbouring meat shop, the first instrument having already been placed in position in the Mission. It worked like a charm, and within a week the proud electrician had received from his friends and acquaintances a dozen orders for similar telephones. He filled orders as rapidly as possible; and as fast as new instruments were completed and put in position those of the Bell Company were removed."

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CONTRIBUTIONS TO THE MOLECULAR THEORY OF INDUCED MAGNETISM.*

BY J. A. EWING, F.R.S.

(*Concluded from page 517.*)

The chief facts of permeability and retentiveness, and hysteresis generally, are therefore at once explicable by supposing that Weber's molecular magnets are constrained by no other forces than those due to their own mutual magnetic attractions and repulsions. No arbitrary constraining forces are required. In the model the centres of rotation are fixed; in regard to the actual solid we may make an equivalent supposition, namely, that the distances between the molecular centres do not change (except in so far as they may be changed by strain).

Hysteresis, then, is not the result of any quasi-frictional resistance to molecular rotations; it occurs whenever a molecule turns from one stable position of rest to another through unstable condition. When it is forced to return, it again passes through a condition of instability. This process, considered mechanically, is not reversible; the forces are different for the same displacement, going and coming, and there is dissipation of energy. In the model the energy thus expended sets the little bars swinging, and their swings take some time to subside. In the actual solid the energy which the molecular magnet loses as it swings through unstable positions generates eddy currents in surrounding matter. Let the magnets of the model be furnished with air-vanes to damp their swings, and the correspondence is complete.

A regular group of elementary magnets, especially when furnished with air-vanes, gives a good illustration of what has been called magnetic viscosity. When the imposed force H reaches a critical value one of the outer members of the group becomes unstable, and swings slowly round; its next neighbours, finding their stability weakened, follow suit, and the disturbance spreads through the group in a way eminently suggestive of those phenomena of time-lag in magnetisation which I have described in a former Paper.†

The model shows equally well other magnetic phenomena which presumably depend on the inertia of the molecules, such as the fact that a given force causes more magnetic induction when suddenly applied than when gradually applied, and leaves less residual magnetism when suddenly removed than when gradually removed.

The well-known effects of mechanical vibration in augmenting magnetic susceptibility and reducing retentiveness are readily explicable when we consider that vibration will cause periodic changes in the distances between molecular centres. This has not only a direct influence in making the molecular magnets respond more easily to changes of magnetic force by reducing their stability during the intervals when they recede from each other, but tends indirectly towards the same result by setting them swinging.

The effects of temperature which are common to the three magnetic metals may be stated thus:—Let any moderate magnetising force be applied, not strong enough to produce anything like an approach to magnetic saturation, and let the temperature be raised. Then the permeability *increases* until the temperature reaches a certain (high) critical value, at which, almost suddenly, there is an almost complete disappearance of magnetic equality. As regards the first effect, it is clear that an increase of permeability is to be expected from the theory; expansion with rise of temperature involves a separation of the molecule centres, and therefore a reduction of stability. As regards the almost sudden loss of susceptibility which occurs at a high temperature, it may do no harm to hazard a rather wild conjecture. We may suppose the molecular magnets to be swinging more or less, the violence of the swings increasing as the temperature rises, until finally it develops into *rotation*. Should this happen, all trace of polarity would of course disappear. The conjecture that the molecular magnets oscillate more and more as the temperature rises, is at least supported by the fact (carefully investigated by Hopkinson* in iron and nickel; data for cobalt also have lately been supplied by Du Bois†) that under *strong* magnetic forces rise of temperature reduces magnetism; for with strong forces the molecular magnets are already ranged so that their mean direction is nearly parallel to H; hence the earlier effect of heat (to diminish stability and facilitate alignment) does not tell, and the increased swinging simply results in reducing the mean value for each molecule of its moment resolved parallel to the magnetising force.

Before referring to effects of stress we may consider shortly the stability of a pair or line of magnets, treating each as a pair of poles subject to the law of inverse squares. Take first a single pair of equal magnets with centres at C and C′ (fig. 7). The poles PP′ would lie in the line CC′, but for the imposed force H, which produces a deflection CC′P′ or C′CP = θ.

Let α be the angle which H makes with the line of centres, m the pole-strength, and r the half length of the magnetic axis of each magnet. The deflecting moment is

$$2Hmr \sin(\alpha - \theta),$$

and the restoring moment is

$$\frac{m^2 \overline{CN}}{\overline{PP'}^2},$$

CN being drawn normal to PP′. The restoring moment at first increases with θ, but passes a maximum at a value of θ

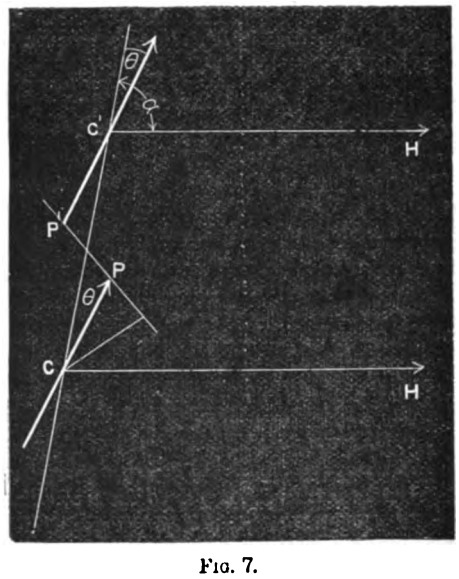

Fig. 7.

which depends on the relation of r to the distance between the centres. The condition of equilibrium is

$$2Hmr \sin(\alpha - \theta) = \frac{m^2 \overline{CN}}{\overline{PP'}^2};$$

and as H and θ are increased the equilibrium becomes neutral, that is to say, the condition of instability is reached, when

$$\frac{d}{d\theta}\{2Hmr \sin(\alpha - \theta)\} = \frac{d}{d\theta}\frac{m^2 \overline{CN}}{\overline{PP'}^2}$$

These two equations serve to determine the value of H and of θ at which instability occurs. If we have to deal with a long line of magnets instead of a single pair, we have to write $2m^2$ instead of m^2 in the restoring moment.

A considerable amount of stable deflection is possible when the distance between the poles is not small compared with r. When the direction of H is not much inclined to CC′ (that is, when α has a value approaching 0) there is no instability. In rows with various inclinations to H, the first to become unstable as H is increased will be that for which $\alpha - \theta$ is equal to $\frac{1}{2}\pi$.

* Paper read before the Royal Society, June 19, 1890.
† *Proc.* Roy. Soc., June, 1889.

* *Phil. Trans.*, 1889, A, p. 443; *Proc.* Roy. Soc., June, 1888.
† *Phil. Mag.*, April, 1890.

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If a, the half distance between the poles in the undeflected position, be small compared with r, there is but little deflection before instability occurs, and in that case, provided α be not small, nor nearly equal to π, the occurrence of instability is defined by the condition

$$\frac{d}{d\theta}\frac{\overline{C}\,\overline{N}}{\overline{P}\,\overline{P'}^2}=0,$$

which is satisfied when $\tan\phi=\frac{1}{\sqrt{2}}$; ϕ being the inclination of PP′ to the line of centres. Hence, with the same proviso (α not nearly equal to 0 or to π, and a small compared with r), the value of H which causes the instability is

$$H=\frac{m}{12\sqrt{3}\,.\,a^2\sin\alpha}$$

for a single pair of magnets, and twice this quantity for the middle members of a long row. This is of course least for magnets which lie normal to H.

In the special case when $\alpha=\pi$, instability occurs when

$$H=\frac{m}{8a^2}$$

with the single pair, or $m/4a^2$ with the row.

Applied to the case of a group of rows, uniform in distance between the centres, but various as regards their direction with respect to H, these considerations show that after H has reached a value sufficient to make the most susceptible members unstable, no very great increase is required to bring about instability in by far the greater number of the other rows. One general effect of increasing the distance between all the centres is to reduce the range of variation of H within which most of the different rows become unstable as the force is progressively increased.

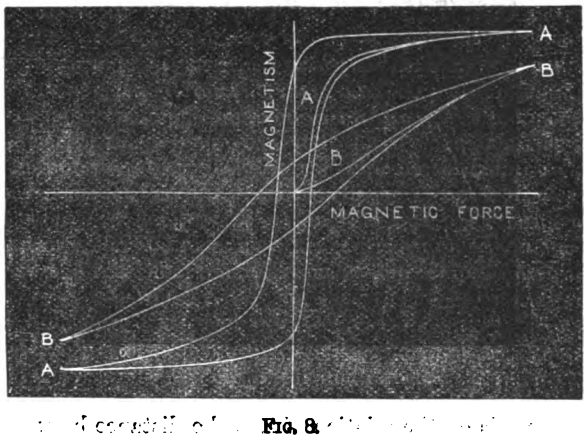

Fig. 8.

In annealed metal, where we may expect considerable general homogeneity, as regards distance between the centres of the molecular magnets, we find that practically the whole of the abrupt stage in the process of magnetisation is included within narrow limits of magnetising force. We accordingly obtain curves like AA (Fig. 8). When the metal is strained sufficiently to receive permanent set the curves take more rounded outlines (such as BB), showing less susceptibility throughout, less residual magnetism, and more coercive force. The most natural explanation of this, on the basis of the molecular theory, appears to be that set produces on the whole a shortening of the distances between molecular centres, hence greater stability and more coercive force; but this is associated with heterogeneity, that is variety in the distances, hence the rounded outlines of the curves. We know that set tends to develop, or at least to emphasize, heterogeneity; for instance, a bar of iron or steel pulled in the testing-machine stretches irregularly after the elastic limit is passed.

The effects of stress and consequent elastic strain on magnetic quality are so complex and so various in iron, nickel, and cobalt, that it would be premature to attempt any full discussion of them from the point of view of the theory now sketched. Only a few general features need be referred to at present. Some of these can be traced experimentally in the model by setting the supports of the magnets upon a sheet of thin indiarubber, which may be stretched or distorted to imitate the conditions of longitudinal or torsional strain.

When pulling stress is applied, those rows of molecular magnets which lie more or less along the direction of the stress have their stability reduced by the lengthening of the lines of centres; similarly, rows which lie more or less normal to the stress have their stability increased. The resulting effect on the general susceptibility of the material will depend on which of these conflicting influences preponderates. Let pull be applied before magnetisation begins, while the metal is still in a neutral state. The stretching of longitudinal lines and the contraction of transverse lines will not only alter the stability of those molecules which continue to lie in their original rows, but will tend to make the members of those rows which are much lengthened swing round and form transverse lines, in which they will be more stable than before. We may, therefore, reasonably expect that the permeability with regard to strong fields will be reduced by pull, as it actually is both in iron and in nickel, though with regard to weak fields the permeability may be increased, as it is in iron.

Again, the theory explains well why the effects of stress are by no means the same (1) when the stress is applied first and the magnetic force after, and (2) when the magnetic force is applied first and the stress after. Let a moderate magnetising force be applied, and then begin to apply stress. The first effects are in general large, for the strain precipitates into instability those molecular magnets which were already on the verge of instability. This is beautifully apparent in iron (see *Phil. Trans.*, 1885, Part II., plates 63 and 64); and the theory shows why the first effects are not reversible, why they do not disappear when the stress is removed, and why it is only in subsequent applications and removals of the stress that the magnetic changes become cyclic. The same remark evidently applies to the first effects of stress on residual magnetism; also to the first effects of temperature-change either on induced or residual magnetism. Again, the theory shows that when a cyclic change of stress is repeated, there will be hysteresis in the corresponding changes of magnetism, whether induced or residual, unless either the cyclic range is very small or the magnetism approaches saturation. During each application of the stress some molecular magnets will swing through unstable positions; during the removal of strsss they will swing back, but not at the same values of stress. And it will be characteristic of this hysteresis that the variation in magnetism will begin slowly when the change from applying to removing stress, or from removing to applying stress, begins. All this agrees with the facts.

Moreover, the theory shows that even in the absence of any resultant magnetisation a cycle of stress makes the molecular configuration pass through a series of changes which will at first not be cyclic, but will become cyclic when the stress-cycle is repeated, and in which any intermediate value of the stress will be associated with different configurations during the going and coming parts of the process. In other words, we see that there will be hysteresis in the relation of molecular configuration to stress when a cycle of stress is repeated. Hence certain rather obscure effects which have been observed in magnetic experiments; for instance, where an iron wire is loaded and partially unloaded down to a given load before being magnetised, its permeability is not the same as when the wire is completely unloaded and reloaded up to the same load. Experimental results of this kind led me in 1884 to write:—"If we apply and remove stress in a wire whose magnetic state is entirely neutral, *we cause some kind of molecular displacement in the relation of which to the applied stress there is hysteresis.*"* The theory now offered shows how this happens. Hence also the remarkable hysteresis which the thermo-electric quality of iron exhibits with regard to cyclic changes of stress, discovered by Cohn, and more fully described in *Phil. Trans.*, 1886, p. 361. The hysteresis of molecular configuration with respect to stress has been proved to be removable or reducible by vibration.

* *Phil. Trans.*, 1885, Part II. p. 614.

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From this theoretical explanation of hysteresis in the effects of stress, it at once follows that a cyclic change of stress (provided it be not very small) involves some dissipation of energy in a magnetic metal, whether the piece be magnetised or not. We may expect this dissipation to be most considerable under conditions which make the magnetic hysteresis large. But it will occur even when there is no external trace of magnetism. This, of course, implies that, in a cyclic process of loading and unloading, work must be spent. There is no perfect elasticity in a magnetic metal, however slowly the process of straining be performed. Under any load there is less strain during application than during removal. This is borne out by experiments on the extension of iron wires (Brit. Assoc. Report, 1889, p. 502). The same action occurs to a marked degree in torsional strains. In a twisted specimen there will be a tendency on the part of the molecular magnets to range themselves along lines agreeing more or less with the direction of maximum contraction. Alternate twisting to opposite sides should therefore cause much molecular swinging through unstable positions, with consequent dissipation of energy, even in a piece which is not magnetised. Without going at present into details, it may be added that the phenomena of molecular "accommodation" studied by Wiedemann and by H. Tomlinson accord with the theory, and that it seems to lend itself well to explain the very remarkable results which have been obtained by Nagaoka* in experiments with nickel wire under twist or under a combination of pull and twist. It also agrees with what little is known as to the influence that previous magnetisation in one direction has upon subsequent magnetisation in another direction.

To sum up, I have endeavoured to show:—

(1) That in considering the magnetisation of iron and other magnetic metals to be caused by the turning of permanent molecular magnets, we may look simply to the magnetic forces which the molecular magnets exert on one another as the cause of their directional stability. There is no need to suppose the existence of any quasi-elastic directing force or of any quasi-frictional resistance to rotation.

(2) That the intermolecular magnetic forces are sufficient to account for all the general characteristics of the process of magnetisation, including the variations of susceptibility which occur as the magnetising force is increased.

(3) That the intermolecular magnetic forces are equally competent to account for the known facts of retentiveness and coercive force and the characteristics of cyclic magnetic processes.

(4) That magnetic hysteresis and the dissipation of energy which hysteresis involves are due to molecular instability resulting from intermolecular magnetic actions, and are not due to anything in the nature of frictional resistance to the rotation of the molecular magnets.

(5) That this theory is wide enough to admit explanation of the differences in magnetic quality which are shown by different substances or by the same substance in different states.

(6) That it accounts in a general way for the known effects of vibration, of temperature, and of stress upon magnetic quality.

(7) That, in particular it accounts for the known fact that there is hysteresis in the relation of magnetism to stress.

(8) That it further explains why there is, in magnetic metals, hysteresis in physical quality generally with respect to stress, apart from the existence of magnetisation.

(9) That, in consequence, any (not very small) cycle of stress occurring in a magnetic metal involves dissipation of energy.

DISCUSSION.

Sir WILLIAM THOMSON said the experiments made by Prof. Ewing were extremely beautiful and important. The fundamental idea of instability of the supposed molecular magnets seemed to be of very great importance indeed in explaining that most fascinating phenomenon known as magnetic induction. Now, that they saw an actual model produced in such an intelligible way, they might well believe in the reality of the molecular conception. What could be realised in steel, wood, iron, and paper, in a model made by human hands was realisable in the molecule itself. They had numerous models for explaining various parts of phenomena in physical science, but nothing in the way of models had so much of richness and completeness of explanation in itself as that which they had seen that day.

Prof. LODGE said Prof. Ewing's discovery was the most important they were likely to have before them in physical science: it got to the bottom of permanent magnetism. That sentence of Maxwell about the molecules being subjected to only their own forces he had endeavoured to attack mathematically; and here Prof. Ewing had attacked it mechanically, and had made one of the most brilliant Papers since Hertz.

Lord RAYLEIGH was not sure that Maxwell dwelt on the magnetic application; but there was a great deal of breaking down of a partially stable figuration, as illustrated in the model which Prof. Ewing had brought before them.

Prof. REYNOLDS expressed his admiration of Prof. Ewing's work. The Professor thought friction had nothing to do with magnetisation of hysteresis; but was he prepared to say that this model had nothing to do with friction? Prof. Ewing had here an opportunity of illustrating the mechanical action which, for want of that opportunity, they lost sight of, and that was that there was an infinitely multiple system of equilibrium of stability; and if they had an equal number of limited stability they would have virtually a quantity which was a friction.

Prof. FITZGERALD said it would be very unfortunate if the general question were confined merely to questions of magnetisation. There were a very large number of allied questions connected with annealing. How could the wire be stretched and obtain some sort of crystalline structure, which when heated and cooled it lost, so that the cycles of heating it and cooling it down was not a cycle of operations that brought it down to the original condition?

Prof. EWING, in reply, said that for some years past he had been very much impressed with the importance of the phenomena to which the name of hysteresis had been given. As soon as this explanation of the phenomena of hysteresis and induced magnetism was produced, it occurred to him that it should be worked out as suggested by Profs. Fitzgerald and Reynolds; and, of course, friction was one of the many instances.

* *Journal* of the College of Science of the University of Tokio, vol. ii. 1888.

RECENT DETERMINATIONS OF THE ABSOLUTE RESISTANCE OF MERCURY.*

BY R. T. GLAZEBROOK, F.R.S.

We are here to-day to discuss some of the determinations of the value of the ohm when expressed as the resistance of a column of mercury, with a view to seeing if any action is practicable by which the standards in general use may be brought nearer to their theoretical value than they are at present. The time is opportune, for we have the advantage of having in Leeds M. Mascart, of Paris, and Prof. Rowland, of Baltimore, under whose directions some of the most important of the investigations we are to consider to-day have been made, and Prof. Barker, one of the American representatives at the Paris Congress. Moreover, it seems probable that a Congress will again meet shortly to consider this question, and a preliminary discussion here may be of value in clearing the ground.

The question at issue is whether the results of experiment are sufficiently in accord with each other to render it probable that any number adopted by us would be generally accepted, and, if so, to determine what that number is.

The problem has two sides. The resistance of a wire is expressed by means of one series of experiments in terms of a length and a time, while by another series of experiments it is expressed in terms of the resistance of mercury; and thus the resistance of mercury is found absolutely. Frequently, however, there is an intermediate step; the resistance of the wire is expressed in terms of some standard resistance, and this standard is expressed in terms of mercury.

The methods employed to compare a standard resistance with that of mercury are all very similar in their nature, and the experiment is not one of very great difficulty. Accordingly we find that the results of the experiments are fairly concordant.

* Printed from notes used for the discussion on Electrical Units in Section A of the British Association, Leeds, 1890.

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TABLE.—VALUE OF OHM EXPRESSED AS THE RESISTANCE OF A COLUMN OF MERCURY.

—	Observer.	Date.	Method.	Value of B.A.U. in ohms.	Value of 100 centimetres of mercury in B.A.U.	Value of ohm in centimetres of mercury.
1	Lord Rayleigh	1882	Rotating coil	·98651	·95412	106·24
2	Lord Rayleigh	1883	Lorenz method	·98677	—	106·21
3	G. Wiedemann	1884	Rotation through 180deg.	—	—	106·19
4	Mascart	1884	Induced current	·98611	·95374	106·33
5	Rowland	1887	Mean of several methods	·98644	·95349	106·32
6	Kohlrausch	1887	Damping of magnets	·98660	·95333	106·32
7	Glazebrook	1882and'88	Induced currents	·98665	·95352	106·29
8	Wuilleumeier	1890		·98686	·95355	106·27
		Mean		·98656	—	—
9	Strecker	1885	An absolute determination of resistance was not made. The value ·98656 has been used		·95334	106·32
10	Hutchinson	1888			·95352	106·30
11	Salvioni	1890			·95332 or ·95404	106·33
12						
	Mean without 12				·95355	106·28
13	H. F. Weber	1884	Induced current	Absolute measurements compared with German silver wire coils issued by Siemens or Strecker.		105·37
14	H. F. Weber	—	Rotating coil			106·16
15	Roiti	1884	Mean effect of induced current			105·89
16	Himstedt	1885				105·98
17	Dorn	1889	Damping of a magnet			106·24
18	Wild	1883	„ „			106·03
19	Lorenz	1885	Lorenz method			105·93

In the Table, column 5 gives the values found in B.A. units for the resistance of a column of mercury 1 metre long, 1 square mm. in section at 0°C.—a Siemens unit as it is called. The values found by Lord Rayleigh and M. Mascart are higher than later ones. A comparison of the values found for the B.A.U. in ohms and for the Siemens unit in B.A.U. by M. Mascart, leads to the conclusion that possibly his B.A.U. had changed a little between the time at which it was compared with the standards at Cambridge and the time at which it was used. As to Lord Rayleigh's value, the fact that the coil F was his principal standard, and that coil F has certainly changed relatively to the other coils in the last two years, may help to explain the difficulty, but it must be remembered that F had the same value relatively to the others in 1888 as it had in 1881, when examined by Dr. Fleming, and some other cause for the difference must be sought. The other numbers are in close accord, except one result of Salvioni's, which must, I think, be capable of a simple explanation. Strecker, Kohlrausch, and Salvioni differ somewhat from Wilkes and myself, in consequence, I believe, of the fact that they worked at the temperature of the room, while Wilkes and I worked at the temperature of melting ice. A small change in the temperature coefficient used by them would easily account for the difference. Wuilleumeier's mercury tubes were the same as those employed by Mascart, Benoit, and de Nerville. We may thus take ·9535 B.A.U. as being very accurately the resistance of a column of mercury 100 cm. long 1 square mm. in section.

But when we inquire what are the results which have been obtained for the value in ohms of the B.A.U., or of the mercury unit, the discrepancies are considerable.

Let us consider the methods. An admirable summary of these will be found in Wiedemann's *Electricitat*, Vol. IV., p. 910, or in Mascart and Joubert's *Leçons sur l'Electricité* II., pp. 581, *et seq.* They have also been critically discussed by Wiedemann and by Lord Rayleigh in the *Phil. Mag.*, Vol. XIV., 1882. We will take them in order.

1. *Kirchoff's Method.*

This has been used by H. F. Weber, Rowland, Mascart, and Glazebrook. The formula may be written

$$R = \frac{4\pi M}{T} \cdot h \cdot \frac{a}{\beta}.$$

Where M is the coefficient of induction between the coils, T the time of swing of the galvanometer needle, a the deflection due to the primary current, β the throw due to the induced current, and h a ratio either of two galvanometer constants, or of two resistances; all small corrections are omitted.

The main difficulty is in calculating the value of M, which depends approximately on a^2/b, if a is radius of either coil and b the distance between the coils.

In the coils used by myself the value of a was about 26 cm.; that of b varied from 12 to 24 cm. An error of ·1 mm. in b produces an error in the result between 1 in 1,500 and 1 in 2,000. In one position of the coils, the correction arising from the fact that the cross-section of the channel was of finite area was less than 1 in 1,000. There should, it seems to me, be no difficulty in finding M to one or two in 10,000. The coils used by Rowland and Weber in their earlier experiments, and by Mascart, were smaller. In his last experiment in 1883 Weber used coils of 32 cm. radius. In their later experiments Rowland and Kimball had large coils, about 50 cm. in radius.

The various results are:—

H. F. Weber	105·37
Rowland	106·29
Mascart	106·33
Glazebrook	106·29

It will be noticed that all H. F. Weber's results are very low. He used as his standard wire a 10-Siemens unit taken from a resistance-box, not a coil which had been compared directly with mercury, and it seems possible that a common error in this affects all his results; he also used large magnets. The other values are in fair agreement, though we may probably agree with Lord Rayleigh in thinking that the limit of accuracy of the method has not been reached.

II.—*Weber's Method.*

The approximate formula again is

$$R = \frac{2\pi G g}{T\beta} = \frac{4\pi^3 N N'}{T\beta} \frac{a^2}{A},$$

where G is the constant of the galvanometer, g the area of the earth inductor, and in the second expression a is the radius of the inductor, A of the galvanometer, N and N′ the number of turns on either.

This method was followed by Mascart, who used with a coil of 15 cm. diameter and a galvanometer the constant for which was compared with one of known constant, viz., the inductor. The time taken to turn the inductor was one-fifth of the time of vibration of the galvanometer needle. There is the difficulty of making the axis vertical and the effect of the time of duration of the current on the throw of the galvanometer needle to consider. My experiments show that if the effect of the induction current be prolonged for a period of one second, the time of swing being 23 seconds, then the deflections are reduced by ·1 per cent. With the circuit open for two seconds effects are marked.

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The same method has been used by G. Wiedemann, who is inclined to think it the best; he employed coils of W. Weber and Zollner, one metre in diameter, which were wound and measured twice. He calculated G, using as galvanometer coil a counterpart of the inductor; the effect of the current was determined by measuring the effects of a series of impulses at proper moments. The time of turning the inductor was two seconds, while the period of the needle was one minute. This would tend to reduce β, this to increase R, and hence to decrease the length of the column, which was found by comparison with a Siemens unit; the same unit was compared with mercury.

Mascart thinks difficulties inspire with doubt the results thus obtained. Experiments near the magnetic equator would, Lord Rayleigh points out, decrease the effect of level error. Wiedemann considers this method is to be recommended for final determinations. Rowland criticises the method.

The results obtained are:—

Mascart	106·37
Wiedemann	106·19

III.—*Method of British Association Committee.*

$$R = \pi^2 N^2 a \Omega \cot. \phi$$

The only measurement, apart from corrections, is that of mean radius. The corrections, however, are important for the self-induction of the rotating coil requires to be known; while the magnetic field in which the coil is moving is modified by the presence of the magnet at its centre, so that the magnetic moment of this magnet has to be determined. In order to reduce the amount of this correction, this magnetic moment is made small, and this again leads to difficulties.

The following difficulties are urged by Wiedemann:—

(1) Correction due to self-induction. (2) Diffiulty of levelling. (3) Want of steadiness from draughts, &c. (4) Small magnetic moment.

In reply we may say

(1) Can be corrected for.

(2) Level error common to several methods. (See II. above).

(3) Effect can be eliminated by experiments with open circuit.

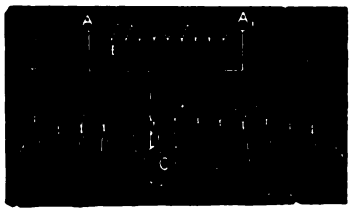
(4) Theory of the correction is very simple; a knowledge of M/H only is required.

The method was used by Lord Rayleigh, leading to the result, 106·24. It was also employed by H. F. Weber, who used rotation about a horizontal diameter in the magnetic meridian to avoid the correction depending on M/H.

IV.—*Foster and Lippmann.*

$$R = 2\pi^2 \Omega \frac{a^2}{A} \cot \phi \, NN'.$$

A rotating coil is used, but contact is made only at the moment when the E.M.F. is a maximum, and E.M.F. is balanced by that due to an external current through a known resistance. Observations have been recently carried out by Wuilleumeier by this method with modifications. He used the induction from a long spiral M N (see figure), 2 metres long 30 cm.



diameter, placed east and west, wound with one layer of wire 2 mm. in diameter. A coil, C, wound on a disc of hard wood, 20 cm. in diameter, rotates in this, and the circuit is closed when the E.M.F. in C is a maximum; the E.M.F. thus produced is balanced against that produced by the current in the spiral when flowing through a resistance, R, the action of the earth's magnetism being compensated. One point, A, of R is in connection with the coil through E, the other end is straight, and a moveable contact is established at A_1, A_2, &c. Corrections for its ends are obtained by shifting the spiral coil. The resistance of R was about ·3 ohm., made from a strip of German silver of rectangular section 34·72 metres long, 1 cm. broad, ·3 cm. thick, immersed in naphtha. The primary current was 12 amperes. A Lippmann electrometer was used. The E.M.F. was nearly four volts. The diameter of the rotating bobbin was 20 cm. Hence, error of 1 mm. in mean radius makes error of one in 1,000. The formula assumes spiral to be uniformly wound. Result is 106·267.

V. *Method of damping.*

Set a magnet in a coil. The motion of the magnet sets up currents which react on the magnet and damp it. A relation can be found between these currents and the rate of damping. To a first approximation, λ λ_0 being logarithmic decrements,

$$R = \frac{\pi}{2} \frac{1}{T} G^2 \frac{M}{H} \frac{(\pi^2 + \lambda^2)}{\lambda - \lambda_0}$$

G has to be compared with the constant of another coil, because of the size of the coil. Let h be the ratio—

$$R = \frac{2\pi^3}{T} \frac{N^2 h^2}{A^2} \frac{\pi^2 + \lambda^2}{\lambda - \lambda_0} r^3 \tan \alpha$$

Where A is the radius of the standard coil, N the number of its turns, α the deflection which the magnet produces in Gauss' first position when at a distance, r.

Further corrections are required for length of magnet, and for the uncertainty as to the distribution of its magnetism and for self-induction. In the opinion of Lord Rayleigh and Rowland, the final formula is enough to show that it cannot compete with the others. Other difficulties are that the calculation assumes the arc of oscillation is small, G is not independent of the displacement. Currents are set up in the magnet, which affect its motion. A correction is required for temporary induced magnetisation due to action of current; this may be appreciable. In general there are difficulties in applying the theory.

The method was used by H. F. Weber. His magnet was 8 cm. long, his coil 16 cm. in radius, and G was calculated, a uniform distribution of magnetism being assumed.

Dorn introduced corrections to the theory, he found G by comparison with a large coil, compared result with a Siemens unit, verified by Strecker; his magnet was 17 cm. long, closely surrounded by the coil. Wild suspended the magnet bifilarly; it was 29cm. long, and the coil closely surrounded it; a resistance-box used.

Kohlrausch's magnet was 20cm. long, with brass ends. The coil was close to it, G was compared with a large galvanometer. Resistance compared directly with a tube calibrated by Strecker.

The results are:—

H. F. Weber	104·77
Dorn	106·24
Wild	106·03
Kohlrausch	106·32

VI.—*Lorenz Method.*

$$R = n M.$$

The main difficulty lies in the calculation of M; this is more easy than in 1, for the disc can readily be measured.

In Lord Rayleigh's apparatus an error in the radius of the coil does not greatly affect result. Further increase of size possible and desirable. The smallness of the effect, and therefore of R is not fatal. See Lord Rayleigh's observations.

Thermo-electric effects can be compensated for.

Results:—

Rayleigh	106·24
Rowland	106·29
Lorenz	106·19

Lorenz value is too low, because of the size of the mercury tubes used by him.

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VII.—*Roiti and Himstedt.*

$$R = n M \frac{a}{\beta} = n 4 \pi^2 a^2 \frac{N N'}{L} \frac{a}{\beta}.$$

There is a difficulty in having many contacts for, if the contact does not last all the time supposed, β would be too small, R too large, and the length of the column too short. There is also an important correction for the ends, and the assumption is made that the coils are uniformly wound. Another difficulty is the theory of the galvanometer under such discharges.

The resistances were compared with a Siemens unit, and in the case of Roiti with one of Strecker's coils.

The results are :—

Roiti	105·89
Himstedt	105·98

VIII.—*Calometric Methods.*

The results by these methods cannot claim any great accuracy.

Having thus completed the review of the methods, we must look at the results; and after what I have said we may, I think, reject all work previous to 1882.

The results of H. F. Weber are manifestly too low, while serious doubts attach to the methods of Roiti and Himstedt. For Weber's first method, the early results of W. Weber and Zollner may be omitted compared with those of G. Wiedemann, while the results given by the method of damping will be sufficiently represented by the work of F. Kohlrausch, who alone of those who used this method compared his results with the resistance of mercury directly. The experiments of Lorenz will not, I think, stand rigid criticism, while, unless I am much mistaken, Lenz, who also used Lorenz' method, has only published results and not details.

We are thus left with the following list, including the results only of those who have made both the mercury and absolute determinations :—

Lord Rayleigh	106·23
Mascart	106·33
G. Wiedemann	106·19
Rowland	106·32
Kohlrausch	106·32
Glazebrook	106·29
Wuilleumeier	106·27
Mean	106·28

If we take in Lord Rayleigh's results for the value of the B.A.U. in ohms, for 100 cm. of mercury in B.A.U. the value ·9535 instead of ·9541, as given by his own experiments, we get, instead of the values 106·21 and 106·24, the values 106·27 and 106·30. The mean, then, of the whole would be 106·29. If we include the three numbers (9, 10, 11) of the table we get the value 106·30.

It seems then, to me, that the number 106·30 certainly expresses the true value within one or two in 10,000, and that the time has come for carrying the conclusions of the Paris Congress one place further. The establishment of the new standardising laboratory calls for some authoritative expression of opinion here in England. Are we prepared to express our opinion?

In 1886, the Standards Committee agreed, on the motion of Sir W. Thomson, (1) to recommend for adoption for a term of 10 years the legal ohm of the Paris Congress as a legalised standard sufficiently near to the absolute ohm for commercial purposes, and (2) that at the end of 10 years the legal ohm should be defined to a closer approximation to the absolute ohm. The Government took no action on this matter, and the opportunity is afforded us of revising, not in ten years, but in four, our provisional suggestion. Shall we replace the 106 cm. by 106·30 c.m. For my part I should be guided greatly by the amount of acceptance that such a decision would meet with. If Prof. Rowland and Prof. Barker, who was with us in 1886, can tell us that they would agree in recommending the Government of the United States to adopt the same view, and if M. Mascart thinks that such a course would meet with the approval of himself and his distinguished colleagues in France, I should be heartily glad of it. If, on the other hand, they press for further time in order that experiments of a higher degree of accuracy—which can no doubt be attained, though probably at great cost—may be carried out, I should deprecate the committee coming to any conclusion which might pledge them to a number which does not meet with general acceptance.

ON THE CHARACTER OF STEEL USED FOR PERMANENT MAGNETS.*

BY W. H. PREECE, F.R.S.

In the discussion which followed the reading of Dr. John Hopkinson's Presidential Address to the Institution of Electrical Engineers, I took the opportunity to point out that the quality of magnetic steel in England had deteriorated, and that it was not to be compared with that produced in France in 1881. This statement was questioned at the time, and I determined to make an exhaustive test of the various steels that are now in the market. Specimens were, therefore, obtained from the leading firms in Sheffield, viz., Messrs. Joseph Ashforth and Co., Messrs. Saunderson Bros. and Co., Messrs. Thomas Jowitt and Sons, Messrs. Vickers, Sons and Co.; Mr. G. P. Wall, and also from the following manufacturers in France :—M. Marchal and M. Clemandot. Mr. Webb, of Crewe, also gave me some samples of the steel used in those works.

The magnetometric method has been followed throughout in this inquiry. Square bars, approximately 10cm. long and 1 square cm. in section, were chosen as test pieces in preference to the long wires, ellipsoids, or other special forms of magnet usually employed in very accurate investigations. These bars are comparable in dimensions with the magnets actually employed for telegraphic purposes; they are very convenient for use with the magnetometer, they can be kept in a relatively small compass for periodical testing, and they enable us to compare the magnetic qualities of different steels with very great accuracy. Although they can only be regarded as approximately solenoidal, yet it is believed that the values of the induction intensity of magnetisation, and specific magnetism, calculated from the magnetic moments of the various specimens, are sufficiently accurate to be of scientific interest. In order to facilitate calculation, it was desirable that the bars should be exactly 10cm. long, by 1 square cm. in section, but it was found that the specimens received could not be worked to this precise size. I have therefore determined their dimensions and weights by careful measurements, and have given the details in the Tables on p. 548. All the English specimens were carefully and uniformly tempered in water in accordance with our usual practice. Of the four magnets made of Allevard steel two were tempered in water, and two in mercury. The Clemandot compressed steel and the Marchal magnets were already tempered and magnetised when received from Paris.

For magnetising the bars a powerful electro-magnet (of a form suggested by Prof. Perry) was employed (*see* Fig.) The coil of the electro-magnet is wound with 136 turns of ·508cm. copper wire, the length of the coil between the cheeks being 9·3cm. The soft iron core is 10cm. long and 3cm. in diameter, and the pole-pieces are 11·5cm. and 3cm. square. The upper pole-piece (which may be removed and replaced by one of a form suitable for maximum induction experiments) is furnished with a thumb-screw and a small movable block, so that the bars to be magnetised may be clamped in position, care being taken that their ends are well faced, and make perfect contact with the pole-pieces.

In the first series of experiments the magnetising current employed was 100 amperes (13,600 ampere-turns), and it was kept on for 30 seconds for each bar.

In the second series the current was increased to 325 amperes (44,200 ampere-turns), and kept on for three seconds in each case. Generally speaking this increased current did not increase the permanent magnetisation of the bars; but, on the contrary,

* Paper read before the British Association in Section A, Leeds September, 1890.

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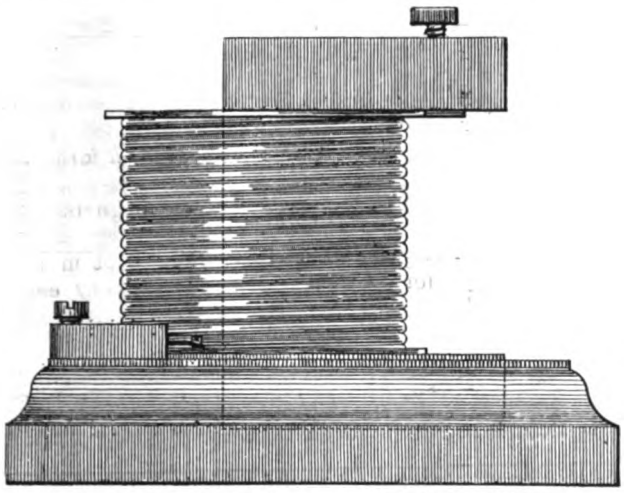
the magnetisation was, in most cases, apparently slightly less than it was after magnetisation with 100 amperes three months previously. The magnetisation of the Clemandot and Marchal magnets was, however, considerably *increased* by the same treatment, as will be seen from the tabulated result of the *experiments*.

The magnetometer employed is simply a Thomson mirror, suitably mounted with levelling screws, and placed over the centre of a millimetre scale two metres long. The scale for reading the deflections is of the usual straight kind with central zero, and is placed at a constant distance of 100cm. from the mirror. The magnets were, in most cases, tested with their centres at distances of 100 and 75cms. from the mirror, the mean of readings on either side of zero in each position was taken. The moments have been calculated from the formula: $M = \frac{H}{2}\frac{(r^2 - l^2)^2}{r}\tan.\ \theta$; r being the distance of the magnet from the mirror, and l half the length of magnet (= 5cms. very nearly). The maximum value of 2θ being only about 4°, tan. θ has been taken as equal to $\frac{\tan.\ 2\theta}{2}$.

The value of H for the room in the General Post Office in which the first series of experiments were made was determined both by the coil method and by the method of vibrations.



Electro-magnet used for Magnetising the Steel Bars.

1. Experiments with a coil of 18 turns, and a mean radius of (15·6) cms. :—

Date.	Current.	Distance of coil from mirror.	Deflection.	Tan. θ.	H.	Mean value of H.
	amperes.	mm.	mm.			
June 12th...	·5	1,000	21·01	·01047	·1268	
„ „	·53	600	96·14	·04803	·1275	
„ 15th...	·5	1,000	20·93	·01046	·1269	·1276
„ „ ...	·47	750	44·79	·0224	·1285	
„ „ ...	·44	600	79·53	·03965	·1282	

2. Experiments with glass hard magnetised wires. H calculated from the formula, $H^2 = \frac{8\pi r K}{T^2 (r^2 - l^2)^2 \tan.\ \theta}$.

June 15th.	Moment of inertia K.	r.	Deflect.	Tan. θ.	Time of complete vibration, T.	H.	Mean.
		mm.	mm.		secs.		
No. 1 wire..	5·6421	400	17·58	·00879	7·075	·1278	
„ 2 „ ..	5·574	„	12·14	·006069	8·462	·1278	·1277
„ 3 „ ..	5·574	„	17·48	·008738	7·062	·1276	

The values of H thus obtained, although agreeing closely with each other, being surprisingly low, the same wire magnets were taken to a spot four or five miles from the G.P.O., and it was then found that their periods of vibration were reduced respectively to 5·99, 7·14, and 5·95 seconds, making H about ·1782, and showing that the previous determinations were fairly accurate.

During the second series of experiments the following values of H were obtained by the coil method :—

Date.	Current ampere.	Distance of coil from mirror.	Mean deflection.	Tan. θ.	H.	Mean value of H.
		mm.	mm.			
Aug. 23.....	·48	1,000	20·09	·010045	·1269	
„ 23.....	·47	750	44·37	·022185	·1·97	·1280
„ 24.....	·455	„	42·70	·021350	·1269	
„ 24.....	·44	„	41·86	·02093	·1287	

Taking the strongest magnets of each group in the second series of experiments, and arranging them in order, we have:—

	Induction.
Marchal, No. 1	2,835
Clemandot, No. 1	2,362
"Allevard," No. 3 (water tempered)	1,879
Ashforth, No. 4	1,779
Jowitt, No. 2	1,745
Wall, No. 4	1,689
Saunderson, No. 1	1,610
"Allevard," No. 2 (mercury tempered)	1,528
Crewe "spring," No. 1	1,436
Vickers, No. 2	1,297
Crewe" rivet," No. 3	217

If we take the mean induction of the magnets of each group, which is probably a fairer method of comparison, we obtain a slightly different order, viz. :—

	Mean Induction.
Marchal	2,540
Clemandot	2,265
Ashforth	1,704
Allevard (water tempered)	1,660
Wall	1,519
Jowitt	1,503
Saunderson	1,435
Crewe "spring"	1,391
Allevard (mercury tempered)	1,315
Vickers	1,174
Crewe "rivet"	186·6

The induction in these short straight bars is comparatively low, because we measure only the lines (Maxwell's B) that radiate from the ends. Prof. Perry has succeeded in getting as much as 12,700 with Jowitt steel, through the middle of a magnet of a special horse-shoe form. It ought, apparently, to be possible to get about 20,000 with the best French steel. I happen to have in my possession two small horse-shoe magnets of Allevard steel which were made for Mr. H. Edmunds, and magnetised in Paris in 1881. The induction of one is now 3,287·3, and of the other 3,552·5. They have never been touched since 1881. The retentiveness is therefore very good.

The marked superiority of the Marchal magnets over those made of English steel is evidently not due to the method of magnetisation adopted by the maker, since their mean induction was increased by 38 per cent., and their magnetisation rendered more uniform by re-magnetisation in our coil. Their greater strength must therefore be due either to the quality of the steel, or to the mode of tempering—most probably the latter. The Clemandot compressed steel magnets, too, which were very poor when first tested, had their mean induction more than doubled by re-magnetisation. In view of the results of these experiments, I purpose to investigate further the methods of tempering magnet steel. It is pretty clear there is room for improvement in our present practice.

I am indebted to M. Trotin, of the French Telegraphic Administration, for having kindly procured the French specimens for me.

All these measurements have been made with great patience and skill by Mr. Henry Hartnell.

DISCUSSION.

Prof. PERRY said that when some months ago, at the Institution of Electrical Engineers, Mr. Preece made a remark about the greatest induction obtainable in comparing the inductions in steel, he thought that gentleman was speaking of the maximum permanent induction that could be obtained; but, of course, he was really speaking of the maximum per-

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RESULTS OF EXPERIMENTS FOR DETERMINING THE MAGNETIC MOMENTS, &c., OF VARIOUS KINDS OF STEEL.

TABLE I.—*First Series: June, 1890.*

Name of manufacturer	No. of specimen.	Weight.	Mean area of poles.	Length.	Volume.	Mean moment M.	Specific magnetism.	Intensity of magnetisation (1).	Induction $(4\pi I)$ B	Mean induction of each specimen.	Remarks
		Grammes	Sq. cm.	Cm.	Cub. cm.						
Wall	1	67·279	·8503	10·025	8·525	985·4	14·65	115·6	1452	1524	Steel split in tempering.
	2	67·235	·8513	10·04	8·547	962·0	14·31	112·6	1414		
	3	66·252	·8446	10·02	8·463	1032·5	15·58	120·8	1517		
	4	66·648	·8487	10·01	8·496	1158·5	17·38	136·4	1713		
Ashforth	1	75·228	·9295	10·00	9·295	1380·5	18 35	148·5	1866	1710	
	2	76·265	·9436	10·00	9·436	1274·5	16·71	135·1	1697		
	3	75·870	·9365	10·00	9·365	1101·5	14·52	117·6	1478		
	4	76 247	·9393	10·03	9·426	1348·8	17·69	143·1	1798		
Saunderson	1	77·962	·9712	10·03	9·750	1258·4	16·14	129·1	1622	1444	One specimen split slightly in tempering.
	2	77·860	·9740	10·03	9·770	1051·0	13·51	107·6	1351		
	3	76·955	·9645	10·03	9·674	1048·7	13·63	108·4	1362		
	4	77·145	·9634	10·03	9·662	1107·8	14·36	114·7	1441		
Jowitt	1	73·928	·9186	10·04	9·222	972·0	13·15	105·4	1324	1522	
	2	74·120	·9249	10·03	9·276	1303·7	17·59	140·5	1766		
	3	72·058	·8995	10·03	9·022	1010·8	14·03	112·0	1407		
	4	73·840	·9214	10·03	9·241	1170·9	15·86	126·7	1592		
Vickers	1	68·631	·8811	10·04	8·846	792·1	11·54	89·54	1125	1158	One specimen failed to stand tempering, one slightly split.
	2	70·043	·9010	10·03	9·037	934·9	13·35	103·5	1300		
	3	66·651	·8589	10·02	8·606	718·7	10·78	83·52	1049		
Crewe "rivet steel"	1	75·751	·9731	9·98	9·711	149·5	1·97	15·40	193·5	180·6	
	2	75·820	·9790	9·97	9·760	162·3	2·14	16·63	208·9		
	3	75·553	·9736	9·97	9·706	149·6	1·98	15·41	193·6		
	4	77·210	·9909	10·00	9·909	99·88	1·29	10·08	126·6		
Crewe "spring steel"	1	75·012	·9763	10·02	9·783	1093·3	14·58	111·7	1404	1364	Two specimens failed to stand tempering; other two badly split.
	2	76·086	·9837	10·02	9·857	1039·0	13·65	105·4	1324		
Clemandot	A1	79·518	...	9·90	9·914	872·9	10·98	88·07	1106	1116	These bars are of compressed steel, tempered and magnetised by the maker; they are rather roughly finished, and their dimensions could only be approximately determined. Tested as received from Paris.
	2	80·335	...	9·95	10·04	968·6	12·06	96·48	1212		
	3	80·208	...	9·98	10·03	956·9	11·93	95·41	1199		
	4	79·94	...	9·96	9·993	1127·1	14·10	112·8	1417		
	5	80·642	...	9·97	10·07	1010·8	12·55	100·4	1261		
	6	79·958	...	9·96	9·995	1284·1	16·06	128·5	1614		
	B7	80·322	...	9·88	10·04	741·2	9·227	73·83	928	928	Compressed, *but untempered.*
Marcnal	1	78·478	·9917	10·00	9·917	1750·7	22·31	176·5	2218	1839	Tempered and magnetised by the maker. Tested as received from Paris.
	2	80·253	1·011	10·00	10·106	1566	19·39	154·0	1934		
	3	79·380	1·014	10·00	10·136	1372	17·28	135·4	1701		
	4	79·540	1·001	10·00	10·01	1645	20·68	164·3	2065		
	5	78·260	·9992	10·00	9·992	1200·5	15·34	120·1	1510		
	6	79·488	1·0006	10·00	10·006	1279·8	16·10	127·9	1607		
Marchal	1	78·478	·9917	10·00	9·917	...	...	...	...	...	.....
	2	80·253	1·011	10·00	10·106	...	...	...	...	...	.....
	3	79·380	1·014	10·00	10·136	...	...	...	...	...	.....
	4	79·540	1·001	10·00	10·01	...	...	...	...	...	.....
	5	78·260	·9992	10·00	9·992	...	...	...	...	...	.....
	6	79·488	1·0006	10·00	10·006	...	...	...	...	...	.....
"Allevard"	1	79·900	·9996	9·86	9·856	878·9	11·00	89·17	1120	1318	Tempered in mercury.
	2	80·415	1·0064	9·87	9·934	1199·4	14·92	120·7	1517		
	3	79·600	·9944	9·89	9·835	1480·5	18·60	150·5	1892	1664	Tempered in water.
	4	79·765	1·0054	9·90	9·954	1138·6	14·27	114·4	1437		

TABLE II.—*Second Series: August, 1890.*

No. of specimen.	Mean moment.	Specific magnetism.	Intensity of magnetisation (1).	Induction $(4\pi I)$ B	Mean induction of each specimen.	Remarks.
1	1003·5	14·91	117·7	1479	1519	
2	946·4	14·08	110·7	1391		
3	1022	15·42	120·7	1517		
4	1142	17·13	134·4	1689		
1	1288	16·72	135·3	1700	1704	
2	1264	16·57	133·9	1682		
3	1103	14·54	131·9	1657		
4	1334·5	17·50	141·6	1779		
1	1249	16·02	128·1	1610	1435	
2	1054	13·55	107·9	1356		
3	1036	13·46	107·1	1346		
4	1099	14·24	113·7	1429		
1	968	13·09	101·9	1319	1503	
2	1288	17·35	138·8	1745		
3	998	13·85	110·6	1390		
4	1147	15·53	124·1	1560		
1	815	11·88	92·12	1158	1174	
2	933	13·32	103·2	1297		
3	730	10·95	84·82	1066		
1	157	2·072	16·16	203	1866	
2	151	1·991	15·47	194		
3	167·5	2·217	17·26	217		
4	104·5	1·353	10·84	132·5		
1	1118·5	14·91	114·3	1436	1391	
2	1056	13·88	107·1	1346		
A1	1864	23·44	188·0	2362	2265	Mean induction increased by 103 per cent. over its original value by re-magnetisation in our coil.
2	1797·5	22·37	179·0	2250		
3	1783	22·22	177·8	2234		
4	1786	22·34	178·7	2245		
5	1738	21·58	172·6	2169		
6	1853	23·17	185·4	2329		
B7	1005	13·26	106·1	1333	1333	
1	1671·5	21·30	168·5	2118	1758	Before re-magnetisation.
2	1495	18·63	148·0	1859		
3	1304	16·43	128 6	1616		
4	1565	19·68	156·3	1964		
5	1135	14·50	113·6	1427		
6	1246	15·68	124·5	1566		
1	2237	28·50	225·6	2835	2540	After re-magnetisation. Mean induction increased by 38 per cent. over its original value.
2	2221	27·67	219·8	2761		
3	1842	23·20	181·7	2283		
4	2147	26·99	214·5	2695		
5	1845	23·57	184·6	2320		
6	1868	23·50	186·7	2346		
1	865	10·83	87·76	1103	1315	
2	1208	15·02	121·6	1528		
3	1471	18·48	149·5	1879	1660	
4	1142	14·31	114·7	1442		

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manent induction when obtained in a tap of a particular shape. He supposed they could not have a fairer way of trying different steels than in comparing them in this way—that is, taking the same size of tap; and they must take the comparative numbers given by Mr. Preece as representing the facts, at all events when the steel is used for magnetic needles, and so on. Whether, however, a different result would not be obtained if the greatest maximum permanent induction were sought after, he was not quite sure. He rather understood from the Paper that the steels were not all tempered in exactly the same way. The English steels were tempered at the Post Office, tempered in water, and perhaps one or two may have been tempered in mercury.

Mr. PREECE: One in mercury.

Prof. PERRY, continuing, said he understood no tempering was done in England in the case of the Allevard steel. He considered that point was of great importance, and he understood that Mr. Preece's own view was that the whole thing may have been due to the tempering. Minute differences had been discovered among the best English steels, which might be due to slight differences in the tempering. Might not the Allevard people have a secret for tempering which we did not have in this country? He had had steel from a certain maker, and wanted to get the best result he could from it. His object was to get the very best induction he could. He had three specimens, which seemed to be of the same material. He tempered one in water, making it as hard as he could. The second he tempered in mercury; but he came to the conclusion that the mercury he tempered it in was not large enough in bulk. The third he tempered in a large quantity of cold mercury; and he found, speaking from memory, three times the induction. It was quite an astonishingly large increase that he obtained from the steel tempered in the large bath of mercury. Mr. Preece was quite right in thinking that a great deal was due to tempering, and that an investigation into the effects of different kinds of tempering might lead to very important results.

Prof. BARRETT said a good deal of this question would be taken up by the Committee on recalescent points. The exact temperature at which the heated steel was hardened by quenching, as well as the rate of quenching, would be found to be important. If quenched short of the recalescent point no hardening ensued, and steel could not be tempered. Hence the subject connected itself with the Committee of which he was Secretary, on the magnetic and other phenomena connected with the recalescent point in steel. He would be very glad if Mr. Preece would favour the Committee with specimens of the steel he was using. Dr. Ball, in a recent Paper read before the Iron and Steel Institute, had shown that both the tensile strength and magnetic properties of steel underwent a sudden change when the steel was quenched at two critical points, one about 700° C., and the other about 1,300° C. In his experiments, Mr. Preece would probably find it very necessary to make use of the thermo couple. The extremely interesting point was the exact temperature at which the steel was suddenly hardened or suddenly quenched in water.

Mr. PREECE said it was his intention to pursue the question of tempering. He was going to take a great number of samples of steel, raise them to different temperatures, and quench them in different cooling mixtures, such as oil, water, and mercury. If anyone wanted any experiments tried, or had any suggestions to make to him, he should be very glad to hear from them.

Prof. PERRY then described a magnet which he had constructed, and of which he subsequently drew the following sketch on the blackboard. He said

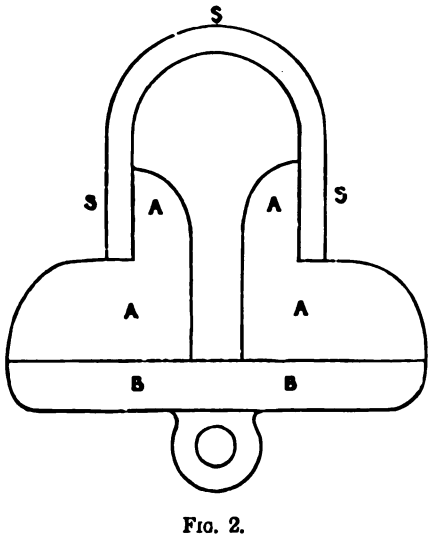

FIG. 2.

that after Mr. Preece's statements at the Institution of Electrical Engineers, he had made it his aim to get the very highest maximum permanent induction that he could. Mr. Preece had spoken of about 1,700 as the usual thing in English steel. He had obtained with English steel about 12,700, and believed that he could have obtained a good deal more by shaping his magnet better. He knew that it was a magnet which would not be employed in any instrument, but for his purposes he thought it was the best. Probably he could scheme a worse. First of all he made experiments in steel, and he found that the harder he made the English steel the better. He had hardened in cold mercury, but if he could harden in something better than that it would be better suited for a great permanent magnetic induction.

Sir WM. THOMSON said he was reminded by Prof. Grey that some years ago in experiments they were making they had experienced great difficulties in getting exactly similar specimens of steel from the same maker. They found the specimens differed exceedingly—10 to 20 per cent.—in their magnetic value, although the maker alleged that they were as nearly the same as he could make them. When they got a very good specimen, and asked the maker to give them more like that, they had very great difficulty in obtaining what they required. One thing they arrived at quite early—that it could not be too hard. He was at first assured that it would not do to make it very hard; specimens were sent, and they did not come up to what he knew they ought to. He sent some specimens back and asked to have them tempered as hard as they could be made. He was told, "We cannot be sure that they will not split;" he answered, "I do not care if it is split along the whole length, give it me as hard as you came make it;" and it was only when he had impressed that idea on the different makers that he got good results. They left the subject in a crudely developed state, and he was exceedingly glad that Mr. Preece had taken it up so effectively. He thought the results would be exceedingly valuable—not merely interesting to science, but very valuable indeed for many important purposes, because notwithstanding what had been said on dynamos, there was still a great career for hardened steel magnets. They reckoned always in intensity of magnetisation, and he wished people would come back to that. The standard result used to be for the very best steel 100 C.-G.-S. intensity of magnetisation per gramme weight; and he was greatly pleased to see such high results as Mr. Preece had put before them. They were enormously better than had previously been supposed to be attainable. One hundred magnetic moment per gramme, multiplied by the specific gravity of steel 7·8 (that was a convenient way to put it), gave them 780 as the magnetic moment per cubic centimetre, and that was formerly considered to be the highest that could be attained. It seemed now that 10 per cent. more than that, and possibly even double that, might be looked for.

SIR WILLIAM THOMSON'S ELECTRIC METER.

The following are a few particulars of the new electric meter shown by Sir W. Thomson to Section G, full details of which we hope shortly to give to our readers:—The general principle may be described as that in which a specimen of the current is chosen at certain intervals and is measured on a counter train. The current is measured on the Weber dynamometer principle. A moveable coil in a shunt circuit, having a non-inductive resistance in series with it, is carried at the top of a long vertical lever or double pendulum pivotted close to its centre of gravity. A "wheel-barrow integrator," consisting of a counter train, whose unit arbor is provided with a rolling disc, forms the counterpoise to the coil. A series coil, fixed to the back of the case, repels the shunt coil as in Sir William Thomson's balances. The lever thus constitutes an inspectional amperemeter. Beneath the counter revolves a large drum, or rather part of a drum or cylinder, the cylindrical surface being cut away in such a manner that the part which is left would, if developed, be the curve representing the movement of the shunt coil for different currents. This drum revolves once in six minutes. When a heavy current is passing, the wheelbarrow integrator is swung in towards the disc which carries the drum, and it rolls on the cylindrical surface for a considerable portion of one revolution. With a smaller current the integrating wheel will touch that part which has been more cut away. The principle and the method by which it is carried out resembles, therefore, the Frager meter, which is extensively used in France, and which was fully described in *The Electrician* of July 11, 1890.

With regard to the fact that as the instrument stands at present it is in a rather expensive form, Sir William Thomson said that the reduction of expense is the life and soul of engineering. Economy must always be considered except in the building of ironclads, and the work of Section A. There work should be done regardless of expense. The construction of standardising laboratories and of the instruments used in them should also be carried out without any attempt at economy. His endeavour was always first to make the most perfect instrument possible, and after it was completed economical considerations might be entertained.

The Telephone in the French Army Manœuvres.—The captive balloon, whose capabilities are being put to the test at the French army manœuvres near Cambrai, is placed in telephonic communication with the troops which it accompanies.

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The Electrician.

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EWING'S THEORY OF MAGNETISM.

Once more must the pen of the chronicler record an important piece of scientific progress. The satisfaction with which the news will be received by the majority of our readers will, doubtless, be redoubled when they learn that the honour of the new advance rests with British science. It is with no new invention that we are confronted; not even with a discovery, in the popular sense of the word. The advance, which is none the less important because as yet it has not indicated the way to any commercial invention, is nothing more or less than a new theory of molecular magnetism. The new theory is acceptable beyond all previous attempts simply because it succeeds, where all previous theories have failed, in explaining the facts upon a simple and reasonable basis. Unlike so many hypotheses which go by the name of theories, the new theory needs no elaborate mathematical symbols to set forth its merits: it appeals to the logic of experiment and to the sense of observation.

To put the matter in a clear light we must go back to the older theories. POISSON'S suggestion that every molecule of a magnetisable body contained two magnetic fluids within it, and that the act of magnetisation consisted in separating the two fluids within each molecule, may be dismissed along with the now-abandoned fluid theories of all kinds. The germ of truth in it was the notion that magnetism was a property resident in the molecules rather than in the mass. AMPÈRE'S brilliant speculation that magnetism consists in the presence of electric currents circulating incessantly around each magnetic molecule is at the present time susceptible neither of proof nor of disproof; but without further assumptions it cannot afford a complete explanation of the known properties of magnets. WEBER bettered the theory of magnetism in two ways. Instead of supposing, with POISSON, that the magnetism of the molecule was something produced in it by the act of magnetisation, he assumed the molecules of an ordinary piece of iron to be always magnets, but that their axes of magnetisation lie indifferently in every direction in a perfectly miscellaneous

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fashion; and that when a magnetising force is applied they simply are turned from their initial positions so as to point more or less in one direction, the whole body thus gradually becoming a magnet. WEBER'S second point was that to such a motion of turning of the molecules there was offered a force of restitution which opposed their change of position, making it difficult to magnetise the body. WEBER'S theory offered some advantages over anything previously proposed. It accounted for the then imperfectly known fact that there is, for each substance, a limit in the amount of magnetisation that can be imparted to it. To this supposition MAXWELL added the suggestion that there might occur, by internal forces resembling friction, something which gave the molecules on being turned a permanent set. This accounted for the coercive force or retentivity shown by certain qualities of iron and steel; for all that was needful to suppose in their case was that in these substances the internal molecular friction was relatively great. In recent years some further attempts have been made, notably by Prof. HUGHES, to elucidate the *modus operandi* of molecular magnetism by observing the effects on magnetisation of subjecting the iron to torsional forces. HUGHES has laid down the view that in iron or steel which has been magnetised, and subsequently demagnetised by violent torsion or vibration, the molecules have rearranged themselves in closed chains or groups, which thereby cease to exercise external actions, their arrangement in molecular circuits having the effect of mutually satisfying their polar forces.

The facts for which any magnetic theory has to account are, however, somewhat complex; and of late years the advances made in our knowledge of magnetic phenomena have seemed to render theorising difficult. The retentivity exhibited by hard steel has been found to be only an extreme case of a much more general phenomenon, known now by the name of *hysteresis*, a phenomenon which has been thoroughly explored by Prof. EWING, to whom we owe, indeed, this useful name. The disappearance of energy which is observed in carrying a mass of iron (even well-laminated iron) through a complete cycle of magnetic operations is another recent fact needing to be accounted for, and suggestive of WEBER'S notion of internal friction. The study of the curves of magnetisation plotted out from observations upon the relative amounts of magnetism obtained with different degrees of magnetising force showed them all to agree in one peculiarity of form. For very small degrees of magnetising force the curves were all nearly straight lines of gentle slope; then they suddenly turned upward, and finally bent over in a sort of knee, as so-called saturation was neared, continuing thence a slow gentle slope upward as before. To find a simple algebraic expression for the complex physical relation indicated by these curves was no easy matter. In vain did MÜLLER, LAMONT, FRÖLICH, and even MAXWELL, essay to lay down a formula. The law of the electro-magnet was not to be so easily brought to terms. The sudden rising of the curve at a certain stage of the magnetisation, showed that as the magnetizing force was increased the iron somehow became suddenly more magnetisable than it was for either smaller or larger forces. A sort of instability or slip was hinted at, which the frictional theory failed to account for. Elastic forces tending to keep the molecules in their original heterogeneous or chain-like grouping might account for the initial proportionality between the force and its effect; but one had to imagine some further action to occur when the proportionality suddenly came to an end. MAXWELL, indeed, seems to have had a glimmering that the force tending to restitution might be due, not to elastic constraint, but to a mutual action between the members of the group of molecules; but this suggestion he left infertile, embalmed between the sines and cosines of WEBER'S theory.

Upon all this maze of ideas a flood of light has now been thrown by Professor EWING. A true descendant of old GILBERT, the father of magnetic science, he has demonstrated by experiment that for which others sought in vain by curious speculation. As GILBERT demonstrated the theory of the mariner's compass by constructing a magnetic model of the globe, so EWING has demonstrated the theory of magnetism by constructing a model of a magnet. He has built up his model by the simple device of procuring a large number of pivoted steel magnets, and grouping them together so that their mutual actions may, on a gross and magnified scale, resemble those of the molecules within a magnetic body. These groups of magnets he has then exposed to the action of an external magnetic force, by surrounding them with a copper wire spiral traversed by an electric current. In this way he has obtained a direct view of the molecular interactions, and possessed himself of the secret that had evaded all mathematical analysis. The molecular magnets arrange themselves, not indeed in rings or chains, but in certain heterogeneous groups, which, under the application of an external magnetising force, are modified. Small magnetising forces cause small motions of nearly proportional amount. Larger magnetising forces may produce such large deflections that some of the needles in the groups will suddenly swing round, having reached a position of unstable equilibrium; but having once turned round they will remain turned, even though the magnetising force is removed. The effects which Prof. EWING has seen and chronicled can be entirely explained by the supposition that the only internal molecular forces concerned are those due to the mutual magnetic forces existing between the members of the groups. One does not need to postulate elastic constraint, nor mechanical friction between the molecules to hold them stuck when turned far round. Internal magnetic forces suffice to account for the whole of the effects hitherto ascribed to internal friction. The whole thing is so simple, so perfect, that its novelty seems almost absurd. Once having learned it, one seems to have known it for years. Strange, indeed, it would be if no one had ever before experimented with a group of compass-needles exposed to external magnetic forces, or noticed their singular and unstable behaviour as the magnetic force was increased. Every one who has a taste for magnetic experiments ought to give himself the pleasure of reading Prof. EWING'S account of his singularly beautiful research, and of repeating the experiments forthwith.

Comparison of Electricity and Compressed Air.—In a Paper recently read before the South Staffordshire Institute of Mining Engineers, an abstract of which appears in the *Journal* of the Iron and Steel Institute, Mr. H. W. Hughes collected details of cost and efficiency of electric transmission of power, and compared them with the cost of pneumatic transmission. At the Chapin Mine, in Michigan, air is compressed to 60lb. pressure at 60° F. by four turbines, and is conveyed through a 24in. pipe for three miles. The pipe cost £12,000, and the total cost of the plant is estimated at £100,000. A test showed 1,430 indicated horse-power at the compressors, and the sum of the indicated horse-power at the mines was only 390; the loss is, therefore, nearly 73 per cent., and this amount does not include friction of the compressors. In a second case a 500 horse-power turbine compressed air and delivered it three miles distant. The efficiency was 32 per cent., and the cost of the plant £84,000. An electrical company (he states) have agreed to give an efficiency of 60 per cent. from a similar turbine for a cost of £17,520, inclusive of the entire electrical equipment.

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SUGGESTIONS TOWARDS A DETERMINATION OF THE OHM.*

BY PROF. J. V. JONES.

"On the whole I am of opinion that if it is desirable at the present time to construct apparatus on the most favourable scale, so as to reach the highest attainable accuracy, the modification of Lorenz's method, last described, is the one that offers the best prospect of success. Before this is done, however, it appears to me important that the value now three times obtained in the Cavendish Laboratory, by distinct methods, should be approximately verified (or disproved) by other physicists. To distinguish between this value and those obtained for instance by Kohlrausch, by Lorenz, or by the first B. A. Committee, should not require the construction of unusually costly apparatus. Until the larger question is disposed of, it seems premature to discuss the details of arrangements from which the highest degree of precision is to be expected."

The above passage, which concludes a Paper communicated by Lord Rayleigh to the *Philosophical Magazine*, in November, 1882, nearly two years before the Electrical Congress in Paris, at which the legal ohm was defined to be the resistance of a column of mercury of 1 sq. mm. section and 1,060 mm. long, seems not to have met with adequate response in this country. So far as published experiments in English laboratories are concerned, the determination of the ohm remains where Lord Rayleigh left it, except for the contribution made by Glazebrook and Fitzpatrick in their measurement of the specific resistance of mercury in terms of the B. A. unit, which is one of the elements in the determination of the specific resistance of mercury in absolute measure by Lord Rayleigh's adaptation of Lorenz's method.

But though in England the scientific world has during the last seven or eight years occupied itself with other things, in other countries, and more especially in America and France, measurements have been made which have confirmed the Cavendish Laboratory result as against the other values mentioned by Lord Rayleigh in the passage quoted. Further, indication has already been given of the intention to employ as the unit of electrical resistance in the new Government Standardising Laboratory not the so-called legal ohm, but the true ohm as nearly as it can be determined; and Major Cardew, in the Paper recently read by him before the Institution of Electrical Engineers, has invoked the assistance of Lord Rayleigh and the British Association Electrical Standards Committee in the preparation of the required unit. The work judged necessary by Lord Rayleigh before the condition of a more accurate determination could be advantageously discussed having been done; and practical necessity for an authoritative determination having arisen in connection with the standardising laboratory, the time seems right for a consideration of arrangements likely to secure high accuracy; and it is with this view that I venture to bring before the Section the suggestions embodied in this Paper.

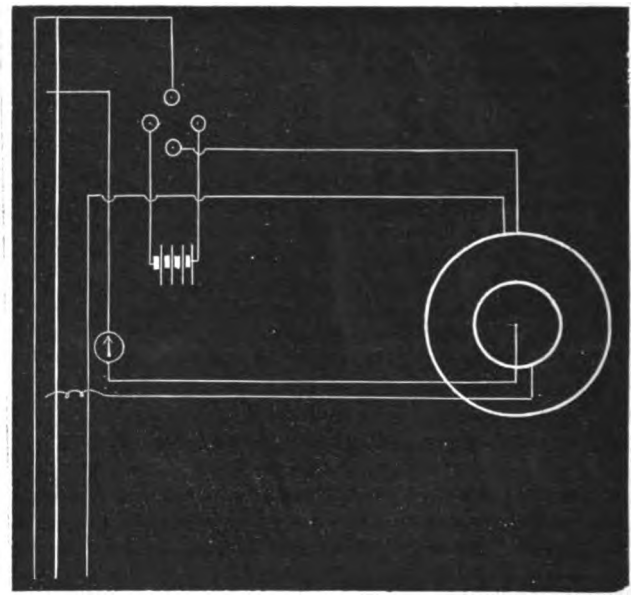
In the hope of paving the way for a more accurate determination (and initially moved to the work by the invitation given in the passage which I first read), I have for a considerable time been engaged in submitting to the test of experiment certain modifications of the method of Lorenz which occurred to me as likely to lead to increased accuracy and certainty. I do not propose to trouble the Section with the details of these experiments, which I hope may be published elsewhere. I mention them merely to give the suggestions brought forward the support derived from a determination actually made on the lines indicated. The experiments have been made in the laboratory of the University College at Cardiff, with apparatus for the most part constructed in the College workshop. Five complete sets of observations were taken in the spring of this year with the following results for the specific resistance of mercury at 0° C.:—

(i.)	94,103 absolute units.	(iv.)	94,045 absolute units.
(ii.)	94,074 " "	(v.)	94,021 " "
(iii.)	94,093 " "		

Mean 94,067 ± 10 (probable error). The result may be otherwise expressed by saying that the ohm is equal to the resistance of a column of mercury of 1 square mm. sectional area, and 106·307 centimetres long, the probable error being ±0·012.

It is far from my intention to bring these numbers forward as the best determination possible by the method I have used. I do not think they at all represent the accuracy attainable if the apparatus were to be constructed on a scale a little larger, and with a certain perfecting of detail. Under such circumstances I am of opinion that a single set of observations will give a result accurate to one part in ten thousand, and that as a mean of a number of observations we may, perhaps, aim at the hundred thousandth if regard is paid to the maintenance of definite temperatures in all parts of the apparatus, and if we can be said to know our lengths standards to this degree of accuracy.

In Lorenz's method a metallic disc is made to rotate in the mean plane of a coaxal standard coil (see diagram). Wires touching the centre and circumference of the disc are led to the ends of the resistance to be measured, and the same current is passed through this resistance and the standard coil. The connections being rightly made we may, by varying either the rate of rotation of the disc or the resistance to be measured, so arrange matters as to have no change of current in the circuit



of the disc and wires joining it to the ends of the resistance when the direction of the current through the resistance and the standard coil is changed. When this arrangement is effected there is a balance between the electromotive force due to the motion of the disc in the magnetic field of the current in the standard coil, and the difference of potential at the ends of the resistance due to the current traversing it. If this adjustment is made, let us say that the apparatus is in an equilibrium position.

If M = the coefficient of mutual induction of the standard coil and the circumference of the disc;
n = the rate of rotation of the disc (number of revolutions per second);
R = the resistance;
γ = the current through the standard coil and resistance;
then, in an equilibrium position,

$$M n \gamma = R \gamma$$

or

$$M n = R.$$

In practice it is not possible to take the coefficient of mutual induction, and the rate of rotation large enough to make the measured resistance more than a small fraction of an ohm*; and

* Paper read before the British Association, in Section A, Leeds, September, 1890.

* Lorenz ·0008 ... ... ·002
Rayleigh ·002 ... ... ·004

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this has usually been regarded as one of the difficulties of Lorenz's method.

In order that the absolute unit may be recoverable at pleasure without the fatigues of a new absolute determination, it must be defined in practice by reference to the specific resistance of some standard substance, and for many reasons there is a consensus of opinion in making this standard substance mercury. The determination of the ohm as a practical problem, therefore, becomes identical with the determination of the specific resistance of mercury in absolute measure, and the small resistance measured by the method of Lorenz's must, in order to complete the investigation, be brought into relation and compared with the specific resistance of mercury. Lorenz himself evaded the difficulty by taking for his measured resistance the resistance of a mercury column contained in a glass tube; the resistance of the column was then obtained in absolute measure, and the specific resistance calculated from the dimensions of the column. It is hardly possible, however, that the latter calculation can have been, or is likely to be, achieved with accuracy, however accurately the tube be calibrated. For, on the one hand, if the wires from the disc (the terminal portions of which may be called the electrodes) are led to the ends of the tube, the equipotential surfaces touched by them are not plane; and, on the other, if they are let into the tube at some distance from the ends, it is difficult to see how the distance between them is to be measured with the requisite accuracy.

Under these circumstances Lord Rayleigh preferred to use solid conductors, overcoming the difficulty of comparing the resistance measured with ordinary standards by a shunt method, which made it possible to express it at once in terms of the B.A. unit. The B.A. unit being thus found in absolute measure, a separate investigation of the specific resistance of mercury in terms of the B.A. unit completed the determination. Rowland and others have adopted the shunt method of Lord Rayleigh, which may be said to be an essential feature in the more probable determinations by Lorenz's method. Spite of the conspicuous success which has attended the use of solid conductors by the shunt method, I venture to suggest a reversion to Lorenz's use of mercury. The physical constant to be measured is the specific resistance of mercury; and if this can, by direct measurement, be determined with accuracy, it seems inconvenient and undesirable first to determine the resistance of the B.A. unit in absolute measure, and then to determine the specific resistance of mercury in B.A. units. If consistently with accuracy the artificial B.A. unit can be dropped out of our experiments as well as out of the result; and the measurements made directly on mercury, the simplicity would seem to be a recommendation, and the argument is perhaps enforced by the consideration that there is very nearly as much divergence in the results of different observers for the specific resistance of mercury in B.A. units as there is in the values obtained for the B.A. unit in absolute measure.

The objections to the use of mercury in a tube are unanswerable; but the difficulties disappear if instead of placing the mercury in a tube, it is placed in a long trough, and if instead of measuring the distance between the two electrodes, one electrode is kept fixed while measurement is made of the distance moved through by the other between two equilibrium positions corresponding to two different rates of rotation of the disc. The latter measurement it is easy to make with accuracy, for the movable electrode may be rigidly attached to the movable headstock of a Whitworth measuring machine or some other measuring bank placed parallel to the length of the trough; and the two equilibrium positions may be taken near the middle of the trough so as to avoid danger of curvature in the equipotential surfaces passing through the electrode in its two positions.

Let n_1, n_2 be the rates of rotation of the disc, and let l be the distance between the corresponding equilibrium positions of the movable electrode.

Then $$M(n_1 - n_2) = \frac{l}{A}\rho$$

where ρ = the specific resistance of mercury.
A = area of section of the mercury column.

But we are met by a new difficulty, the determination of the section of the mercury column. The capillary depression at the sides of the trough would make it a most serious task to determine the section by direct measurement to the required degree of accuracy.

Fortunately, this difficulty may be overcome by a further differential method, viz., by making observations with the mercury at two different heights in the trough.

Let b = the breadth of the trough;

$h_2 - h_1$ = the difference of height of the mercury surface in the two cases;

and let A = the section of the mercury column when the mercury is at the lower position.

Then we have, denoting by dashed letters, the new values of the rates of rotation and the distance between the corresponding equilibrium positions—

$$M(n_1 - n_2) = \frac{l}{A}\rho$$

and $$M(n'_1 - n'_2 = \frac{l'}{A + b(h_2 - h_1)}\rho$$

whence eliminating A

$$\rho = \frac{M\, b\, (h_2 - h_1)}{\frac{l'}{n'_1 - n'_2} - \frac{l}{n_1 - n_2}}$$

It is assumed in the above formula that the sides of the trough in that part of it traversed by the movable electrode are plane, parallel, and vertical.

Hence the determination of the specific resistance involves the determination of:—

(i.) Four equilibrium positions, two at each depth, with the rates of rotation of the disc to which they correspond.

(ii.) The breadth of the trough in that part of it traversed by the movable electrode.

(iii.) The difference of level of the mercury surface at the two depths.

(iv.) The co-efficient of mutual induction of the coil and disc.

The difficulties attached to the determination of equilibrium positions and the coefficient of mutual induction belong to all forms of Lorenz's method, whether the resistance measured is that of a solid conductor or that of a mercury column. Those specially incident to the use of a mercury column are:—

(i.) The manufacture of an accurate trough, and

(ii.) The accurate measurement of the difference of level of the mercury surface in its two positions.

The trough used by me in the experiments of which I have spoken, was cut in paraffin wax contained in a strong casting of iron with its sides strengthened by outside ribs. The channel is approximately 43·5in. long, by 1·5in. broad, by 3in. deep. It was first cut by a cutter rotating about 2,000 times a minute, attached to the slide rest of the College Whitworth Lathe, and subsequently finished by a scraper, attached in similar fashion, which took a very thin cut off sides and bottom. The result of the scraping was a very smooth and highly-finished surface.

This method of obtaining a channel for the mercury was adopted in the hope that, so cut in the lathe, it might present a breadth constant to two or three ten thousandths of an inch. This hope was not realised; the results of subsequently calibrating the trough over the 10in. of it traversed by the movable electrode indicated a variation of as much as ·001in. in its breadth. The objections to the use of paraffin wax are:—

(i.) Its softness makes it necessary to proceed with great care in measuring its breadth, lest damage should be done to the surface. This difficulty is satisfactorily surmounted in the form of internal callipers adopted in the calibration, which I must not stay to describe.

(ii.) The coefficient of expansion of paraffin wax is very large, its linear coefficient of expansion being about ·0003. A change of temperature would, therefore, cause distortion in the wax channel, seeing that the wax is enclosed in an iron casing.

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We endeavoured to meet the danger of inaccuracy due to this cause by measuring the breadth of the trough as nearly as possible at the same temperature as that at which the electrical observations were made, care being taken to maintain the trough at a uniform temperature throughout the observations. During the month of the observations, the temperature inside the box in which the trough was placed did not vary more than half a degree. But, notwithstanding this care, I am of opinion that the difference in the result of different sets of observations depends in the main upon variations in the trough due to varying temperature. But it is impossible to apply a correction, for paraffin wax is so bad a conductor of heat that its temperature could not be assumed to be that of the thermometers in the mercury channel; its temperature at any part would really be a function of ancient history.

Under these circumstances, I have come to the conclusion that I made a mistake in my choice of a substance; the disadvantages outweigh the apparent ease of construction. Probably a much more satisfactory result would be obtained by building up the trough of worked glass or scraped marble. I do not doubt that a sufficiently accurate trough might be made in either of these substances without straining the resources of the English mechanical engineer. We may observe that small errors become of less importance as the breadth of the trough is increased; and nothing but practical convenience limits the size of the trough we may employ, provided it is long enough in proportion to its breadth to make the equi-potential surfaces plane over the part of it traversed by the moveable electrode. It is further to be noticed that it is only the latter part of it that needs to be finished with the highest accuracy, and when the mechanical engineer has done his best, it is still possible to obtain a further approximation by a process of calibration.

The position of the mercury surface in the trough may be determined electrically by means of a pointed steel spherometer screw. The screw may be moved downwards until an electric circuit, comprising the screw and the mercury, is completed. It is of the utmost importance that the point of the screw should be kept clean, and that the mercury surface should be free from an oxide film, otherwise successive observations may differ from one another as much as ·001in.; but with clean mercury, if the point is carefully wiped with filter paper before making the observations, half a dozen observations may be without difficulty obtained, none of which differ from the mean by more than ·00004in. To preserve the point, sparking at the mercury surface should be reduced as much as possible. In order that the capillary surface should be of the same shape at both levels, the surface should always be brought to its measured position by pouring mercury into the trough, and never by taking mercury out of it.

I am of opinion that both the measurements to which I have referred as peculiar to the direct use of mercury by the differential method—viz., that of the breadth of the trough and that of the difference of level of the mercury surface—may be made with an accuracy which will compare favourably with that which we can hope for in the determination of the equilibrium position; and, perhaps, also with that which we may expect in the measurement of the coefficient of mutual induction—measurements which are common to all forms of Lorenz's method. Probably, also—though here I speak with hesitation and without experience—the accuracy will be as great as, if not greater than, that which attends the calibration of a glass tube, necessary to the determination of the specific resistance of mercury in B.A. units.

The electrical observations in Lorenz's method consist, fundamentally, in the determination of equilibrium positions, together with the rates of rotation to which they correspond. The equilibrium position is obtained when, if the direction of the current is reversed through the standard coil and trough, the reading of a galvanometer inserted in the disc circuit is unaffected. In the experiments I have made, I have found it best—following Lord Rayleigh—to take two sets of galvanometer readings for each equilibrium position, one set giving the change of galvanometer reading corresponding to reversal of the battery current for a position of the electrode slightly to one side of the equilibrium position; the other, the change of galvanometer reading corresponding to reversal for a second position slightly on the other side of the equilibrium position. The galvanometer reading corresponding to the two positions of the commutator being called E and W, passage through an equilibrium position is indicated by a change in the algebraic sign of W – E. When W – E has been found for two positions slightly differing from one another, and including between them the equilibrium position, the latter may be found by simple interpolation. Since the readings, E and W, are not quite fixed, owing to small changes in the speed of the disc and variations at the brush contacts, it is necessary to take a number of reversals and to find W – E as the mean of the values obtained by combining the first value of E with the first of W, the first of W with the second of E, the second of E with the second of W, &c. The more quickly the reversals can be made to succeed one another, the better will be the results, for with rapid reversal variations in the position of the needle corresponding to no current through the standard coil (*i.e.*, variations due to change at the brush contacts), are less likely to supervene. It is, therefore, best not to wait for the needle to come even approximately to rest after the disturbance due to the induction current on reversal, but to take the readings for the extreme positions in an oscillation, and having previously found the coefficient of damping, to calculate the position of rest from these two readings.

The whole difficulty in determining an equilibrium position arises from the want of constancy in the readings E and W; and this want of constancy is due to two causes:—

1. Variations in the electromotive force at the brush contacts.
2. Variations in the rate of rotation of the disc.

It was with a feeling akin to despair that I watched the dance of the galvanometer needle during the first running of my apparatus, when the brush at the circumference of the disc was composed of a number of layers of thin phosphor bronze sheet controlled by a spring, and the dance continued, however well the circumference of the disc and brush were amalgamated at starting. Trials were made in the hope of improvement with amalgamated copper and amalgamated lead, and with the substitution of a dead weight pressure for the spring. But no satisfactory result could be obtained. It was noticed, however, that after amalgamation the readings were fairly steady for a short interval, and it occurred to me that if mercury could be continuously supplied to the surface of contact between the brush and the disc, this steadiness might be maintained. This led on to the idea of a brush consisting of a single wire perforated by a channel through which a constant flow of mercury might be maintained from a cistern of adjustable height; and a brush of this description was finally adopted. It presents very great advantages over any other form of brush tried.

Prof. Rowland used three brushes on the circumference instead of one, and I do not doubt that a multiplication of brushes is advantageous. Three or more such brushes as I have described, resting by dead weight pressure on the circumference of a disc ground true in place, would, I believe, give an excellent result. The grinding of the disc in place is an important aid to steadiness of galvanometer reading.

It is to be noticed that the value of W – E for a position at a given distance from the equilibrium position is proportional to the current through the standard coil. Hence the small variations due to the brush contacts which do not at all depend on the current through the coil become proportionately of less importance as the current is increased. We ought, therefore, from this point of view, to use as large a current as possible. But the magnitude of the current is limited by the fact that it has to traverse the wire of the standard coil, which must not be made so hot as to risk the destruction of its insulation. This consideration points to the use of wire of considerable diameter in the standard coil. If the wire of the coil is made of large diameter, attention must be paid to the influence on the coefficient of mutual induction of the non-coincidence of the current with the axis of the wire.

The second cause of want of steadiness in the galvanometer needle is variation in the rate of rotation of the disc; and this is the real crux. We are not helped in determining the equilibrium position either by increasing the sensitiveness of the galvanometer or the magnitude of the current through the coil,

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unless we procure a corresponding increase of steadiness in the running of the disc. We may increase the value of W – E for a position at a given distance from an equilibrium position in either of these ways; but unless there is a corresponding improvement in the constancy of the disc rotation no advantage results, for the variations in W and E resulting from changes of speed are proportional to W – E. Hence in the construction of apparatus for a new determination, mechanical engineers should be invited to do their very best to procure a constant rotation. No time or trouble spent in securing this will be lost for the purpose in view.

In my experiments the disc was turned by an electromotor directly coupled to it, and driven from a battery of secondary cells. Each bearing was fitted with sight feed lubricators, and a heavy steel flywheel was attached to the motor. The current passed to the motor through resistance coils, and could be varied continuously through a small range by a slide resistance of platinoid wire, after the larger adjustment had been made to obtain a speed, approximately that which was required. A shunt worked by a lever also provided the means of taking out or putting in a small resistance suddenly, so as to allow the observer taking note of the speed to counteract small variations, due to alteration in the lubrication of the bearings.

To obtain improved steadiness, the chief point needing attention is lubrication. Some forced system of lubrication may be employed. Either oil may be pumped through the bearings, or they may be fed from a cistern placed at some height above them. Attention might also be directed to the friction of the brushes on the motor commutator. I do not think we can look hopefully to an increase of steadiness from the employment of any hand brake controlled by the observer, for the mischief is done, and the alteration has come about before he observes that it is his duty to put the brake on or off. In fact, the galvanometer needle picks up the alterations much sooner than the observer's eye. An electro-magnetic brake might be useful for adjusting the speed, but could not give any additional steadiness to the galvanometer needle. This can, I think, only be procured by perfection of mechanical workmanship, and increased attention to the truth of all rubbing surfaces, and their proper lubrication.

It remains to speak of the measurements necessary to enable the calculation of the coefficient of mutual induction to be performed. To facilitate an accurate determination of the mean radius of the standard coil, I desire to suggest that it should be a coil consisting of one layer of wire. The advantage in constructing a standard coil with a single layer of wire is that every part of it is visible, and that nothing is done to alter the position of the wire after measurements are made. If a coil consists of many layers, it is not quite easy to say where, after measurement, the lower layers go to under the pressure of the superincumbent layers. Lord Rayleigh found, in the case of certain coils used by him, that the mean radius calculated from measurements made in winding was greater by one part in 2,000 than the mean radius calculated from measurements made in unwinding, a result clearly due to the compression of the lower layers by the layers above them. We should, therefore, expect that if the mean radius of a coil of many layers is calculated from measurements made in winding, it will be reckoned too large. In the face of this, it is interesting to note that in the measurements made by Lord Rayleigh by the method of Lorenz, the series in which the coils are so placed as to make the induction coefficient nearly independent of the mean radius, gives a result rather larger than the other series, which is what might be expected, if the mean radius is over-estimated. But the smallness of the variation (a little over one part in 10,000), seems to show that the error of mean radius must be very small for the pair of coils used by Lord Rayleigh. In general, we should expect, as far as this cause goes, that values of the specific resistance in determining which coils of many layers are used would come out too low, since an over-estimate of the mean radius of the coil means an underestimate of the coefficient of mutual induction. The apparent disadvantage of a coil of a single layer is that the number of turns will be fewer; and, therefore, the coefficient of mutual induction of the coil and disc smaller than in the case of a coil of many layers. We may, however, in order to get a sufficient number of turns, make the coil of greater axial length than has been customary. But we cannot, in that case, use Lord Rayleigh's formula of approximation in calculating the coefficient of mutual induction. Under these circumstances, a new formula, applicable to a coil of moderate axial length, was a desideratum. Such a formula I obtained by the direct integration of the expression $\int\int \frac{ds\,ds'}{r}\cos\epsilon$ for a circle and coaxal helix.

It is of the form

$$M = -8n\pi\frac{Aa}{A+a}\Sigma(-1)^m\frac{1.3.5..2m-1}{2.4.6...2m}\cdot\frac{1}{2m+1}\left(\frac{x}{A+a}\right)^{2m}Pm.$$

Where A = the radius of a circular section of the cylinder determined by the helix.
a = the radius of the circle.
n = the number of turns of the helix.
$2x$ = the axial length of the helix.*

and $$P_m = \int_0^{\frac{\pi}{2}}\frac{\cos 2\theta\, d\theta}{(1-c^2\sin^2\theta)^{\frac{2m+1}{2}}}$$

when $$c = \frac{2\sqrt{Aa}}{A+a}$$

P_m may be expressed in terms of c, F (c), and E (c).

This is the formula I have used in calculating the coefficient of mutual induction of the coil and disc in the experiments already mentioned. The coil is of double silk-covered copper wire of about ·02in. diameter, resting in a screw thread of ·025in. pitch, cut on a hollow cylinder of brass of about 21in. external diameter. The axial length of the cylinder is something over 4·5in., and 185 turns of wire are wound on it. The disc has a radius of about 6·5in., and the coefficient of mutual induction is about 17,000in. This is a little more than a tenth of the coefficient of mutual induction of the coils and disc used by Lord Rayleigh in the first and second series of his experiments by the method of Lorenz, but it was found to be ample for the purpose in hand.

The mean radius of the coil was measured in the Whitworth measuring machine.

Uncertainty arose from two causes :—

(1). The silk covering of the wire;

(2). The ellipticity of the coil cylinder.

The silk covering of the wire is of slightly varying thickness, and suffers compression to a varying extent during a series of measurements.

A standard coil, consisting of naked wire wound in a screw thread cut on a cylinder of insulating material, would be preferable to one of covered wire wound on a metal cylinder. There is, however, difficulty in finding a suitable insulating material. Wood immediately occurs to one's mind, but a large coil of wood, even though it be built up many pieces, is apt to change its shape with age and varying atmospheric conditions. But if a suitable insulating material, that can be turned true and that will retain its shape can be found, a single layer of naked wire in a screw thread cut on a cylinder of this material, would give us a coil the mean radius of which might be easily measured with certainty in the Whitworth machine to far more than one part in ten thousand.

The ellipticity of the coil cylinder deserves notice. The cylinder was turned with great care in the lathe already mentioned. It was cast with three lugs by which to bolt it to the face plate, and subsequently in precisely similar fashion to the strong brass frame which serves as its support during use. The first operation was roughly to fit the lugs to the face plate by filing. A roughing cut was then taken over the entire surface of the cylinder, so as to get rid of as much as possible of the internal strain due to unequal cooling of the casting. It was next unbolted and the lugs were carefully scraped to fit the face plate, and after again bolting it to the face plate the final turning was proceeded with. Very fine

* *Phil. Mag.*, January, 1889. Read before Physical Society, November 10, 1888.

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cuts were taken in finishing, and it was hoped that by these precautions we should secure a true right circular cylinder. Nevertheless, measurements made in the Whitworth measuring machine show that the section of the cylinder at right angles to its axis is slightly oval. The longest diameter is 21·1056, and the shortest 21·0898, from which it appears that there is a difference of about ·008in. between the longest and shortest radius. It appears, indeed, to be a task of no ordinary difficulty to turn a cylinder of large size that shall remain true to the thousandth of an inch. Every fresh cut seems to alter its internal equilibrium, and after the cut is complete it adjusts itself to a new shape. The remedy lies in having a sufficiently massive cylinder carefully annealed to work on, and a fund of patience to make the requisite number of fine finishing cuts with a sufficient interval of time between them. In conclusion, the main suggestions I have to offer for consideration are the following:—

(I.) That the time is ripe for a new determination of the ohm that shall be final for the practical purposes of the electrical engineer.

(II.) That such a determination may be made by the method of Lorenz, the specific resistance of mercury being obtained directly in absolute measure by the differential method described.

(III.) That the standard coil should consist of a single layer of wire, the coefficient of mutual induction of the coil and disc circumference being calculated by the new formula.

EXPERIMENTS TO DETERMINE WAVE VELOCITY IN CERTAIN DIELECTRICS.*

BY F. T. TROUTON.

The method employed was described in *Nature*, February 21, 1889, and depends essentially on interposing a sheet of the dielectric between the reflector and the resonator in Hertz's well-known experiment of electro-magnetic "loops and nodes." The effect of this is to move in towards the reflector the system of maximum and minimum sparking positions. The amount of the displacement thus resulting depends on the rate of propagation of the disturbance through the dielectric sheet.

In the experiments made the sheet was placed immediately in front of the reflector. The circular form of resonation was employed to determine the position of the "loops and nodes," and it was always held so as to be only effected by the magnetic component.

If the reflection, which occurs at both surfaces of the sheet, be neglected, (μ) the index of refraction will be found by dividing (l) the thickness of the sheet into its air equivalent $\mu = \frac{(x_0 - x)}{l}$ where x is the distance from the sheet to the first node or magnetic minimum position, and x_0 the distance of the node from the reflector when the sheet is removed—that is to say, one-quarter the wave-length in air.

When the reflection from the surface of the dielectric is considered the expression for μ is not quite so simple. If we suppose the metallic reflector in optical contact with the dielectric sheet, we can then sum up the multiple reflections resulting, very much as in the well-known way of doing so for Newton's rings. Let the amplitude of the incident radiation be taken as unity, and let b be that of the reflection at the front surface of the sheet, and c of the part penetrating. This portion on reaching the metallic reflector is supposed returned, and at the front of the sheet is again divided; let the part reflected back to the metal be $c\,e$, and that sent out $c\,f$, and so on. The reflected wave is found by summing up these terms. If $\sin\phi$ is taken to represent the incident radiation at the front surface of the dielectric, the total reflection then is $b \sin\phi + c\,f\{\sin(\phi+\delta) + \epsilon^2 \sin(\phi+2\delta) + \epsilon^4 \sin(\phi+4\delta) + \ldots\}$, where $\delta = m\,2\,l\,\mu$, m standing for $\frac{2\pi}{\lambda}$. This can be written as $A \sin(\phi + 2mr)$, when $\tan 2m = r\frac{(1-b^2)\sin\delta}{(2b+(1+b^2)\cos\delta)}$. This give for μ, remembering that $b = \frac{(\mu-1)}{\mu+1}$; $\tan 2mr = \frac{2\mu \sin 2m\mu l}{\{(\mu^2-1)+(\mu^2+1)\cos 2m\mu l\}}$.

Here r is the equivalent distance in air, or $r = x_0 - x$.

Some experiments have been made with sheets of pitch, solid paraffin, sulphur, and plaster of Paris. In the case of pitch, the value of μ calculated from the above results is about what would be expected, namely, about 1·7 (Hertz by means of his pitch prism found 1·69); but in the case of the others the calculated values of μ are evidently much too large, those for paraffin and sulphur lying between 3 and 4. The area of the pitch sheet was 60 by 45c., that of the paraffin and sulphur 60 by 29c.; the thicknesses were 6·3, 3·5, and 3c. respectively. The zinc reflector placed behind the sheets was the same size as the sheets. It may be due to the small sizes employed that these unsatisfactory results were obtained, the small size of the reflector introducing diffraction phenomena—that is to say, the first node is situated at more than $\lambda/4$ from the reflector. This is due to the electrically-charged edges of the metal reflector. This is more fully referred to in *Phil. Mag.*, March, 1890. An approximate calculation of the action of such a reflector can be obtained by supposing it equivalent to a Hertz vibrator; in this way are obtained values for the velocity of the disturbance near the reflector greater than the normal. It may possibly be that these abnormal velocities (or whatever may be the true phenomenon which is equivalent to such) are effected in a greater ratio than the normal velocity is by the substitution of other dielectrics for air. In fact, taking Hertz's value for the velocity at distance ν as $v = V\frac{m^2\nu^2+1}{m^2\nu^2}$, we find something of the kind. For a dielectric whose index of refraction is μ, $v_1 \quad V_1\frac{m^2\nu^2\mu^2+1}{m^2\nu^2\mu^2}$; and the value of the index at distance ν, $\mu_\nu = \frac{v}{v_1} = \mu\left(\frac{m^2\nu^2+1}{m^2\nu^2+\frac{1}{\mu^2}}\right)$. This gives μ_ν as greater than μ the normal value.

It must, however, be remembered that at the distances in the present case the formula can hardly be satisfactorily applied. The thing might be experimentally tested by placing the sheet at a little distance in front of the reflector. There is no question but that the employment of larger dielectric sheets and metal reflectors, so as to give the equiphasial surfaces plane instead of curved, will be the best solution of the main enquiry.

When there is a space left between the dielectric sheet and the reflector, the calculation is more complicated than before, owing to the reflection from the back of the dielectric as independent of the metal. In the following this distance is supposed nothing but the back reflection from the sheet left. The result can be written as $\tan 2m\nu = \frac{A\sin\alpha + C\sin\gamma}{A\cos\alpha + \cos\gamma}$, where A is the amplitude of the reflection from the dielectric sheet alone, the metal being removed, and α the alteration in phase introduced; and where C is the amplitude of the point resulting from replacing the metal reflector, and γ the alteration in phase belonging to it. A and α are found precisely as in Newton rings.

$$A^2 = \frac{2b^2(1-\cos\delta)}{1-2b^2\cos\delta+b^4} \qquad \tan\alpha = \frac{b^2-1}{b^2+1}\cot\frac{\delta}{2}$$

To find C, let the transmitted beam be written as $B\sin(\phi+\beta)$ when

$$\tan\beta = \frac{\sin\delta}{\cos\delta - b^2},$$

and suppose this returned by the metal reflector. Part of this will be transmitted by the sheet, and part sent back a second time to the metal. The part transmitted is $B^2\sin(\phi+2\beta)$; the part reflected back to the metal is $AB\sin(\phi+\beta+\alpha)$. This

* Paper read before the British Association in Section A., Leeds, September, 1890.

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is again reflected by the metal, and is again divided up. The part transmitted is $A B^2 \sin(\phi + 2\beta + \alpha)$; the part reflected is $A^2 B \sin(\phi + \beta + 2\alpha)$ and so on. Then we have to solve

$$C \sin(\phi + \gamma) = B^2 \{\sin(\phi + 2\beta) + A \sin(\phi + 2\beta + \alpha) + A^2 \sin(\phi + 2\beta + 2\alpha) + \ldots \ldots \}$$

and summing up we get the values of C and γ. Putting in for the sines their exponential values and recollecting that $B^2 = (1 - A^2)$ we get $C^2 = \frac{(1 - A^2)^2}{1 - 2A\cos\alpha + A^2}$ and $\gamma = 2\beta + \tan^{-1}\frac{A \sin\alpha}{1 - A\cos\alpha}$.

The calculations of μ from this result in practically the same values as given above. In the case of some substances it was found quite impossible to make a determination of μ after the method described, as they afforded of themselves such strong reflection. Glass even 2c. thick gave considerable reflection, as did also a limestone flag 2·5c. thick. Slate and sandstone gave reflection, but not so strong as the other two. A sheet of coal 2·5c. gave very slight reflection, but a sheet of thin battery carbon reflected like metal. No reflection could be obtained from ebonite 2·5c. thick, shellac 2c., or tallow, pitch, paraffin, or sulphur. This reflection is doubtless due to absorption of the beam reflected from the back surface, which thus weakened cannot sensibly interfere with that from the front surface. Owing to the nature of the apparatus and the fact of its constantly changing in sensitiveness, no precise measurements are possible, but a considerable number of comparisons between different substances were made in this wise. The resonator was set so as to only just spark on placing, say, a sheet of glass behind it as reflector, then quickly a sheet of, say, sandstone, and again glass. In this way it could be found that while glass caused sparking the sandstone did not. A cell (adjustable as to thickness) made of cardboard, which could be filled with various substances in a broken-up state, such as quartz, sand, chalk, lamp-black was tried. When 2c. thick no reflection, or hardly any, was found with sand, fair reflection with chalk, and lamp-black gave as "good as the limestone flag." Before the chalk was well dried it seemed to give stronger reflection. These sheets were about 1ft. square. Some quantitive method, such as that used in Germany by Rubens and Ritter, but which could be applied on a small scale, would be desirable, for these experiments are necessarily of the very roughest sort.

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"Journal of the Iron and Steel Institute." No. 1. 1890. (London: E. and F. N. Spon.)

"Screw Threads and Methods of Producing them." By Paul N. Hasluck. Third Edition: re-written and enlarged. (London: Crosby Lockwood and Son.)

Prague.—A report, says *Industries*, has been issued by the Vienna Elektrotechnischer Verein, showing the present condition of electric lighting in Prague and the neighbourhood. From this it appears that at the end of last year there were 8,365 glow lamps and 143 arc lamps in various factories, theatres, and restaurants. These were supplied with current from 47 dynamos of a total capacity of 425 kilowatts. The motive power was partly derived from steam engines and partly from gas engines, the proportion of the latter being 23 per cent.

A NEW FORM OF VOLTA PILE, USEFUL FOR STANDARDISING OPERATIONS.

In exhibiting this instrument before Section G last week, Sir William Thomson said that Prof. Rowland had described a similar arrangement, but the one he had brought to the meeting contained several improvements in the details and mounting, which were the outcome of constant use in the laboratory.

Four hundred staples, constructed with one limb of copper and the other of zinc, were mounted in an ebonite frame, standing on four wooden legs. The adjacent staples were set at a distance less than $\frac{1}{10}$in. apart, their ends pointing downwards. A copper tray, with handles, was placed below the frame, and contained water. On lifting the tray, so that the ends of the staples were immersed, and lowering it again, a drop of water was left hanging by capillary attraction between the zinc and the copper of the adjacent couples. The whole then formed a simple battery of four hundred cells. The battery was not made for giving a current, but was used with an electrometer, and saved a great deal of trouble and expense compared with the setting up of a number of ordinary batteries. It had been found to be particularly useful in measuring the capacity of cables. The volts were found to be very constant from element to element, and any number could be readily taken, or they could be divided into two or more sets by means of a plug, which was merely pressed in between any pairs.

BRITISH ASSOCIATION.

DISCUSSION ON ELECTRICAL UNITS.

The reading of Mr. R. T. Glazebrook's Paper on "Recent Determinations of the Absolute Resistance of Mercury" (*see* page 543) and of Prof. Viriamu Jones' Paper on "Suggestions towards a Determination of the Ohm" (*see* page 552) before Section A, on Friday, 5th September, gave rise to the following discussion:—

Prof. HENRY A. ROWLAND, Ph.D., said, as one of the members of the United States Commission for the determination of the ohm, the matter was entrusted to his hands, the Commission consisting of Prof. Barker, Prof. Trowbridge, and himself. The experiments were carried out at the John Hopkins University, under his own supervision, with a considerable appropriation from the United States Government. The experiments had been in progress for very many years, for although the results were here given of what they originally determined—the first experiments, he might say—yet they had continued to investigate the subject to the present time; and, indeed, the whole matter had been gone over by one of his associates, who was a professor of applied electricity; and he and the students had determined not only the absolute unit, but they had made the complete determination of the mercury unit once more. He was sorry that he did not make preparations for this occasion. He had been travelling abroad for many months now, and he had made no preparation, nor had he brought any figures with him. All he could say was that the students had gone over the figures very carefully; and he thought that the number of 106·32 had been slightly diminished. He thought that it was more like the mean which Mr. Glazebrook gave; but his own recollection was not sufficient to be certain on the point. Dr. Duncan had also gone over the experiment, and got very nearly the same result. The apparatus had been brought to the John Hopkins Laboratory, where they could experiment, and the results were very similar to the mean that Mr. Glazebrook gave upon the board. He had no doubt himself that this was very near to the figure. Mr. Glazebrook had gone over it so carefully, and his criticisms had been so exhaustive, that he could say very little more with respect to it. They were agreed as to the best method, Lorenz's, and the results obtained by that method he thought agreed now and were of very great accuracy. The Commission of the United States would be perfectly willing to recommend the figures, based upon the experiments so far determined. They would recollect that the United States Commission never recommended to the United States Government any figures whatever. The 106 which was decided upon at the Paris Congress of 1884 was never accepted by the United States, even provisionally; and therefore the matter had been left entirely open up to the present time. But they felt sure that they would come to some figure of that sort, and therefore they were prepared to recommend some figure based upon the results here given. He might mention that the new superintendent of the Coast Survey had intimated to the Commission that the Government was willing to establish a standardising bureau under the charge of the United States Coast Survey.

Lord RAYLEIGH, Sec.R.S., said he felt rather antiquated when he saw his name at the head of the list of 18 with his 1882 and 1883 observations. He thought Mr. Glazebrook was right in beginning at that point. Before 1882 the results were comparatively wide. At that time the discrepancies reached 3 per cent. It was very satisfactory to find that the question was now narrowed to about 1 in 1,000, instead of 3 in 100.

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From the figures put before them it certainly looked very much as if his number for the specific resistance of mercury (·9541) was rather too high. The observations were, however, carefully made, and agreed well among themselves, though the conditions were considerably varied. Since the publication of Mr. Glazebrook's measures in which the same method and, to a large extent, the same apparatus was employed, he had gone very carefully into the matter in the hope of finding where the difference between them lay, but he had been unable to find any material error in the larger number. A reduction to ·9539 might perhaps be admitted, on account of imperfect cooling to zero of the extremities of the mercury column. He quite agreed with Mr. Glazebrook that the balance of evidence was in favour of 106·30 as representing the length of the column of mercury equal to an ohm; but he thought we could hardly regard this as certain to ·02. Perhaps too much relative importance was attached to the ascertainment of this number. If we knew to 1 in 100,000 the value of the ohm in terms of mercury, what use could we make of our knowledge? The electrician did not find it convenient to set up a mercury tube to obtain the standard, and in a factory still less would mercury be employed. To make any use of the determination they must have a wire. Thus, in Prof. J. J. Thomson's recent investigation of "v" the reference to mercury does not enter, but only the relation between the B.A. unit and the ohm. From this point of view it was satisfactory to find so good an agreement between the numbers obtained by various observers for the latter ratio. The only other thing that occurred to him to say was that he did not understand why so much more importance seemed to be attached to the determination of the ohm than of the ampere or volt. For the former we had a long series of measures carried out in all parts of the world. But, so far as he knew, the ampere still rested upon the work of Kohlrausch and himself. He suggested to those prepared to tackle these questions the further determination of the ampere, which was liable to more uncertainty than the ohm.

Prof. BARKER said that he had been struck with the justness of Mr. Glazebrook's conclusions which had been placed before them, and for which the Section should be under very great obligations. He felt that they in the United States occupied a somewhat anomalous position with regard to the ohm. When the Congress of 1881 determined to submit to experimental determination in the various countries the determination of the length of the mercury column, its work was undertaken on behalf of the United States by our Commission and the work was delegated to Prof. Rowland. A great deal of care was devoted to the work, and it occupied some time, and in consequence it was delayed; and when the meeting in April, 1884, took place the Commission petitioned for a further postponement in order to enable the results of the experiments to be presented to the Paris Conference. However, the action was taken in Paris upon results which did not include the American observations, so that the Americans had no part nor lot in the 106 centimetre ohm; and therefore they might be supposed to be entirely independent as to whether 106 should be adopted or not. It was a very fortunate thing that the English Government took no action in the recommendation of the British Association four years ago. He had the great pleasure of assisting at that Committee, and he supposed that the pressure of having some legalised standard led to the suggestion of Sir William Thomson that 106 should be adopted. It seemed in view of the knowledge of that time extremely desirable that the standard adopted should come up to our then actual knowledge, and 106 was conceded to be actual knowledge. It was therefore an opportune time now to take decided action—to take legal action; and he was glad to unite with Prof. Rowland to express the opinion that the United States would be very glad to adopt 106·3 with the Committee of the British Association, and to recommend it for adoption as the legal ohm. It would be a great satisfaction if M. Mascart should secure simultaneous action in France in the same direction. He hoped that this would be done. With reference to the remarkable address of Sir Frederick Abel as to the state of electrical matters in the United States he felt in common with his countrymen. He felt that they were very much indebted to England for the work that had been done, and particularly the British Association and its Committees, for the present state of affairs. He might be allowed, although not germane to the discussion, to refer to another matter in which they in the United States, having so large an interest in electrical matters, felt some concern. It would be remembered that at the Congress of 1881 the name Weber was taken away from the unit of current, and the name of Ampère substituted. At that time he suggested that America was entitled to some representation of that sort, and he suggested the name Franklin for one of those units; and, although a Professor seconded the suggestion, it was not thought desirable. He would simply now, *per contra*, in reply to Mr. Glazebrook, suggest that the United States should support England in 106·3, and that England should support the name of Franklin (applause).

Sir WILLIAM THOMSON, F.R.S., said that from some things that had passed it might be thought that he was a partisan of 106; but he begged to say that he was not. He thought that Mr. Preece would bear him out that they both fought for 106·25 at the Paris Congress; but it turned out that the case was 106 or nothing. The German scientists and instrument makers desired that the Siemens unit should be left. Sir William Siemens and Dr. Werner Siemens were present, and they desired very much that a mercury unit should be kept, and showed very good reasons for keeping it so. The mercury unit, then, was adopted; and the question was, How many centimetres instead of the Siemens' 100 was to be taken for the new unit? It so happened that there were no observers present whose results went above 106, although there were a considerable number of distinguished men there from Germany and Italy. The average of all the results before the Congress came to almost exactly 106. He urged very hard that Lord Rayleigh's was worth all the others put together, and he believed he persuaded the minds of some of the Congress, but he could not get them to vote for it. Four years ago he proposed a 10 years period, and that was carried by the British Association. Electricians did not live so fast then as now, and he was glad to find that these last four years had done the work of 10 years; and he cordially agreed with Mr. Glazebrook, and Prof. Barker and Prof. Rowland in feeling very thankful indeed that the British Government did not take any action on the resolution of the British Association four years ago. He cordially concurred in the idea of what was held by persons present and perhaps by all the best judges, that now had come the time for fixing the standard at 106·3. That was much nearer than 106·2 or than 106·4; he thought they had reason to believe that it was one or two parts in ten thousandths of the true value. As to the British Association method, he did not know that there would be any proposal to go on with more elaborate methods; but if any more great experiments were to be made he would say again for the British Association method that they had not yet seen all that it could do. The question of levelling the instrument had been carefully considered by Clerk-Maxwell and himself. They had come to the conclusion that the proper place to make the measurement was the Equator, and Maxwell was quite ready to go there to do it. If he had been spared it would have been kept in view. Going to the Equator would greatly increase the sensibility, and it would do away with all trouble in the matter of level. If further observations were to be made by the British Association Committee he hoped that they would be made at the Equator rather than at Cambridge. He would call attention to the very remarkable agreement among the results of able observers whose work had been described by Mr. Glazebrook, operating by different methods.

Mr. W. H. PREECE, F.R.S., said that to a certain extent he must accept the responsibility of having advised H.M.'s Government to decline to adopt the 105 as the legal unit in 1886. The reasons for that course were very powerful and very numerous. To make any change, unless it were a change that would ensure absolute accuracy, would have meant serious and unnecessary expenditure. The number of B.A. rheostats, the number of instruments of all sorts and kinds adjusted to the B.A. unit, not only in this country but in all its Colonies and all over the world, was so very great, that if any change were made would have been a matter involving, one could not say how many, thousands of pounds, and it would certainly involve another change within 10 years. He was quite certain that the course he adopted was right. There was no doubt whatever that a change then would have been wrong, but on the other hand, there was equally no doubt that at the present moment they should be perfectly right in accepting the change. After listening to what Mr. Glazebrook had said; after following nearly all those investigations, and considering the matter with Lord Rayleigh, Sir William Thomson, and others, at the present moment he should not have the slightest hesitation in recommending those associations with which he was connected to take 106·3 as the length in centimetres of a column of mercury of one square millimetre sectional area as representing the true ohm. They must remember this, that although it might not be absolutely accurate, it was more accurate than most of those instruments of measurement that they daily used. It was much more accurate than a foot-rule that most engineers carried in their pockets; it was infinitely more accurate than a thermometer, by which so many observations were made. If they took any ordinary instruments of measurement, he thought they could say that their electrical standards of measurements far surpassed them all in accuracy. Lord Rayleigh wanted to know why they did not measure the ampere. Of course the measurement of the ampere was not only dependent upon the accurate measurement of the ohm, but also upon the accurate measurement of the volt; and when they had a volt represented as accurately as they should now have the ohm, then they might fall back upon the ampere. At the present moment the only standard measure of E.M.F. was a measurement of the Clark's cell made by Lord Rayleigh himself; but that one was not so accurate as the mean results brought before them that day. The discussion before them took in view general electrical units not alone that of the ohm. He did not wish to raise any discussion on that point. They had quite enough to decide in what should be the ohm. But he wanted electricians to take into consideration the necessity, at some future day, of considering the entire alteration of the volt. It was a most unfortunate thing that the volt was taken to be ten to the power of eight C.G.S. units (10^8). It was done because that particular force and the E.M.F. of the Daniell cell were nearly alike. If it had been ten to the power of nine instead of eight (10^9), and our unit were practically accurate, the ampere would have been exactly the same as the unit C.G.S. current that was used in nearly every magnetic inquiry. The day was not far distant when all electricians would have to take into consideration the enlargement of the volt; and it would have this advantage, that it would also enlarge at the same time other units. For instance, the watt was too small. To use the watt as a unit of power they had to call it a kilo-watt. If they raised the volt to the power of nine then the watt would become nearly one-eighth of a so-called horse-power—it would, in fact, be a *man-power*—and they would have a unit of power that would be scientific in its accuracy. With respect to Prof. Barker's suggestion they were all agreed in this: That if it was possible to slip in Franklin anyhow, they would do so. But Franklin was not the only American who deserved this honour. There was Henry; and it had been suggested in America and carefully considered by others that the use of the word Henry might very well be applied to the unit of self-induction. It was not yet before the Committee; but if any new nomenclature was wanted, the names Franklin and Henry should certainly receive careful consideration.

Mr. SWINBURNE asked whether it would not be better to measure the resistance of a mercury trough made at random, and then to submerge an insulating cylinder. A cylinder can be made much more accurately than a trough by the method used in grinding calender rollers, or even by turning. To get rid of thermo-electric effects in the disc arrangement, a double disc with a conducting band connection might be used, making the errors cancel out.

LORD RAYLEIGH said he was very much interested in Prof. Jones's Paper. When he himself first planned the observations by the method of

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Lorenz, he cast about to see whether he could imitate Lorenz, and deal with an actual column of mercury. He found several difficulties which at the time shook him off, and which Prof. Jones had overcome. He was quite confident that good results could be obtained by Prof. Jones' suggestions. It was a distinct variation upon the methods used by others. Prof. Jones had brought mercury directly into the actual measurement. He was not quite sure whether he rightly understood Prof. Jones as to the manner in which the connection with the mercury column was made. What he attempted in his own experiments to do was this:—He took a glass tube about an inch in diameter, and in order to get the lateral connections which constituted the difficulty, he divided the tube—cut it as clean as he could by a file in two places into two parts; and then filing a groove in the edges, he put them together again with a thin layer of cement, leaving in that way the cavities through which the lateral wires could be introduced. The disturbance of the regular section produced in that way was not much; and if gone into in a more careful manner good results might be got. Prof. Jones had used an open trough with a free surface. That seemed satisfactory. The only remark that occurred to him, as Prof. Jones explained his method, was this: that it seemed to require four observations to get a result. That rather accumulated errors of reading, but probably not to any serious extent. He had very little doubt that extremely accurate results might be got; and, if the Professor pursued the subject, he would surpass what had been already done. As to the temperature of the mercury, in using a fine tube there was no difficulty in immersing it in ice. As to the temperature of Prof. Jones's experiments, he did not know what it was. Was it zero?

Prof. JONES: No; it was 15·5deg. throughout.

LORD RAYLEIGH: I have no doubt the correction to zero is made with a good deal of accuracy, but it takes away something from the directness of the method.

SIR WM. THOMSON said there was one point in Prof. Jones's method which might possibly be the source of not negligible error, viz., the meniscus. No doubt Prof. Jones would attend to that, but it would be necessary to see that the error from meniscus should not vitiate the results. In respect of temperature, he should have thought that the determination might be had with great accuracy by thermometers in the mercury itself at points a considerable distance from the parts subjected to the differential test. If it were two or three times the breadth of the trough, the distance from the point where the current was tapped they would produce but little electrical disturbance. He was glad that Lord Rayleigh advised Prof. Jones to pursue the method, and to seek for still further results, which seemed so far so exceedingly satisfactory.

LORD RAYLEIGH said he appreciated the immense advantage of reducing the coil to a single layer. There was also the question of the uniformity of the winding in the other direction.

Prof. JONES: No; it is on a screw frame.

LORD RAYLEIGH: I suppose, then, that matter may be taken as quite satisfactorily provided for.

Prof. JONES then replied. He said with regard to the temperature he admitted Lord Rayleigh's proposition. The real determination was the specific resistance of 15·5deg. The two thermometers were placed in the troughs as Sir W. Thomson had mentioned, one at one end of the trough and one at the other, just in front of the iron plates: and the mean of these temperatures were read before and after each set of galvanometer readings. With regard to the capillary surface it must be remembered that a very slight variation in the capillary angle would make a difference. The trough in his own experiments was 2½in. in breadth, and might be made 5in. or 6in. in breadth in order to eliminate more errors. Nothing but the practical inconvenience of having so large a trough limited the breadth. Probably the suggestions of Mr. Swinburne with regard to the regulations of speed might be useful.

Dr. GLAISHER, in closing the discussion, thanked Mr. Glazebrook and Prof. Jones for the very able communication they had made. He had no right to say anything himself on that subject; but in reference to Lord Rayleigh's remarks about their being no practicability in such great accuracy, he thought that an accuracy of one in a ten thousandth part was something; and he hoped it would be determined by Prof. Jones to the extent of showing the difference that a few years could affect in accuracy when the ablest intellects were at work upon it.

THE MAGNETO-OPTICAL GENERATION OF ELECTRICITY.*

BY SAMUEL SHELDON, PH.D.

While experimenting upon the effects of alternating currents of electricity upon the plane of polarised light, results were obtained which made it feasible to try a series of experiments in which the Faraday arrangements were reversed. Although the series is incomplete, yet the little that has been accomplished seems worthy of publication.

It is well known† that if a beam of plane polarised light be passed through a tube containing bisulphide of carbon, and if the tube and beam lie in the direction of the lines of force of an electromagnet about to be excited, the plane of the emergent beam will be rotated upon exciting the magnet. The direction of rotation will be the same as that of the exciting current, and the amount of rotation will depend upon the strength of the current. If the current be reversed, the plane will be rotated in an opposite direction and by exactly the same amount. Thus the rapidly alternating current would produce a rapid swinging to and fro of the plane of light.

Now, if a difference of potential, under these conditions, produces such a rotation of the plane, why should not a rapid rotation of the plane under exactly the same conditions produce an inverse difference of potential between the terminals of the coil? A continuous rotation should produce a continuous current of electricity and an oscillating of the plane an alternating current. The experiments which have been performed verify the latter supposition.

The coil employed was wound upon a thin brass tube as a core. This was closed at each end by plates of glass and was provided with holes for filling with carbon bisulphide. Its length was 175mm. and its diameter 23mm. Upon this was wound the coil from double silk-covered copper wire of 0·85mm. diameter. When wound the length of the coil was 150mm. and its diameter 45mm. The resistance was 7·21 ohms.

A quantitative measurement of the Faraday effect was first made, and in the following manner:—A beam of light from an incandescent lamp, after passing through a large Nicol, was made to traverse the bisulphide of carbon in the coil. Upon emerging the beam was brought to extinction by the proper adjustment of an analysing nicol. A measured current of electricity was now passed around the coil. This necessitated a readjustment and rotation of the analysing Nicol to reproduce extinction of the beam. Within the limits tried, this rotation was proportional to the current strength. As a mean of many measurements, it was found that a current of 1 ampere required a rotation of 78 minutes of the analyser. Accordingly, 278 amperes would be required to rotate the plane through 360°, providing the proportionality between current strength and rotation remained unaltered.

Now, if we consider a plane polarised ray of light to be made up of two opposite circularly-polarised rays, then a particle of ether in the bisulphide of carbon describes a simple harmonic oscillation in a plane. This motion in a straight line is the resultant of the two oppositely directed, equiperiodic, circular rotations of equal amplitude. If now a magnetic field be created, the particle undergoes an instantaneous circular electric displacement which results in the retardation of one and the acceleration of the other component rotation. The line of oscillation suffers rotation as a result, and assumes a new position. The displacement must be instantaneous, for, were it continuous, the line of oscilation would continue to rotate, and the analyser could not be made to produce extinction. If now, instead of allowing the magnetic field to produce this circular displacement, we superimpose, by mechanical means, a third rotation upon the two existing components, then a magnetic field should result, and an electromotive force be induced in a coil surrounding that field. Such a result would be obtained by rotating the polarising Nicol. The rapidity of rotation must be very great, and if it requires 278 amperes (an impressed electromotive force of 2,000 volts) to rotate the plane through 360°, then to produce this electromotive force the polariser must be revolved with a frequency of the same order as of the oscillations of light. But a Nicol cannot be revolved much above 200 times per second. The centrifugal force resulting from a higher rate will, owing to the strain produced, interfere with the performance of its functions as a polariser. This rate of 200 revolutions per second would produce, in the apparatus employed, an electromotive force of perhaps 0,000,000,001 volt, giving a current too small to be detected by any galvanometer in my laboratory. Hence use was made of the extreme delicacy of the telephone as a substitute, and a swinging of the plane instead of a revolution.

The arrangement of apparatus was as follows—Light from an arc lamp, after passing through a large Nicol, was reflected, at a very obtuse angle, from a small movable mirror, and then passed through the bisulphide of carbon in the coil before mentioned. The two terminals of the coil were carried to a room three stories below, and in another part of the building. Here they were connected through a telephone and a switch. The mirror (10×30mm) was fixed in a brass frame, free to rotate about an axis nearly parallel with the ray of light. This frame was connected by an eccentric and gears to the main shaft in the workshop. By this arrangement the mirror was made to oscillate through 45deg., about 300 times each second. The plane of polarisation was thus twisted through twice that amount, or 90deg., in the same time. While this oscillation was going on in the workshop, an ear placed at the telephone at the other end of the circuit could easily distinguish a tone, which, however, was the octave above that made by the moving mirror. When the circuit was broken the sound ceased to be heard, but upon again closing the tone became audible. With a rate of 200 oscillations per second the note was not so easily distinguished. But upon closing the circuit that peculiar sizzling noise so common in telephone circuits was heard.

During the experiments the mirror was frequently broken by the high rate of vibration. But another was quickly substituted by my assistant, Mr. Baker, whom I have to thank for this and the construction and management of the rotating apparatus.

* From the *American Journal of Science.*

† Faraday, *Exp. Res.*, 2,146, Vol. III., p. 1.

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THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

(Continued from page 528.)

HISTORICAL SKETCH *(continued)*.

At the date of Sturgeon's work the laws governing the flow of electric currents in wires were still obscure. Ohm's epoch-making enunciation of the law of the electric circuit appeared in Poggendorff's *Annalen* in the very year of Sturgeon's discovery, 1825, though his complete book appeared only in 1827, and his work, translated by Dr. Francis into English only, appeared (in Taylor's "Scientific Memoirs," Vol. II.) in 1841. Without the guidance of Ohm's law it was not strange that even the most able experimenters should not understand the relations between battery and circuit which would give them the best effects. These had to be found by the painful method of trial and failure. Pre-eminent amongst those who tried was Prof. Joseph Henry, then of the Albany Institute, in New York, later of Princeton, New Jersey, who succeeded in effecting an important improvement. In 1828, led on by a study of the "multiplier" (or galvanometer), he proposed to apply to electro-magnetic apparatus the device of winding them with a spiral coil of wire "closely turned on itself," the wire being of copper from $\frac{1}{40}$th to $\frac{1}{25}$th of an inch in diameter, covered with silk. In 1831 he thus describes[33] the results of his experiments:—

"A round piece of iron, about $\frac{1}{4}$ of an inch in diameter, was bent into the usual form of a horse-shoe, and instead of loosely coiling around it a few feet of wire, as is usually described, it was tightly wound with 35ft. of wire, covered with silk, so as to form about 400 turns; a pair of small galvanic plates, which could be dipped into a tumbler of diluted acid, was soldered to the ends of the wire, and the whole mounted on a stand. With these small plates the horse-shoe became much more powerfully magnetic than another of the same size, and wound in the same manner, by the application of a battery composed of 28 plates of copper and zinc, each 8in. square. Another convenient form of this apparatus was contrived by winding a straight bar of iron, 9in. long, with 35ft. of wire, and supporting it horizontally on a small cup of copper containing a cylinder of zinc; when this cup—which served the double purpose of a stand, and the galvanic element—was filled with dilute acid, the bar became a portable electro-magnet. These articles were exhibited to the Institute in March, 1829. The idea afterwards occurred to me that a sufficient quantity of galvanism was furnished by the two small plates, to develop, by means of the coil, a much greater magnetic power in a larger piece of iron. To test this, a cylindrical bar of iron, $\frac{1}{2}$in. in diameter and about 10in. long, was bent into the shape of a horse-shoe, and wound with 30ft. of wire; with a pair of plates, containing only $2\frac{1}{2}$ sq. in. of zinc, it lifted 15lb. avoirdupois. At the same time a very material improvement in the formation of the coil suggested itself to me on reading a more detailed account of Professor Schweigger's galvanometer, and which was also tested with complete success upon the same horse-shoe; it consisted in using several strands of wire, each covered with silk, instead of one. Agreeably to this construction a second wire, of the same length as the first, was wound over it, and the ends soldered to the zinc and copper in such a manner that the galvanic current might circulate in the same direction in both, or, in other words, that the two wires might act as one; the effect by this addition was doubled, as the horse-shoe, with the same plates before used, now supported 28lb.

"With a pair of plates 4in. by 6in., it lifted 30 lbs., or more than 50 times its own weight.

"These experiments conclusively proved that a great development of magnetism could be effected by a very small galvanic element, and also that the power of the coil was materially increased by multiplying the number of wires without increasing the length of each."[34]

Not content with these results Prof. Henry pushed forward on the line he had thus struck out. He was keenly desirous to ascertain how large a magnetic force he could produce when using only currents of such a degree of smallness as could be transmitted through the comparatively thin copper wires such as bell-hangers use. During the year 1830 he made great progress in this direction, as the following extracts show:—

"In order to determine to what extent the coil could be applied in developing magnetism in soft iron, and also to ascertain, if possible, the most proper length of the wires to be used, a series of experiments was instituted jointly by Dr. Philip Ten Eyck and myself. For this purpose 1,060ft. (a little more than one-fifth of a mile) of copper wire of the kind called bell wire, ·045 of an inch in diameter, were stretched several times across the large room of the Academy.

"*Experiment* 1.—A galvanic current from a single pair of plates of copper and zinc 2in. square was passed through the whole length of the wire, and the effect on a galvanometer noted. From the mean of several observations, the deflection of the needle was 15deg.

"*Experiment* 2.—A current from the same plates was passed through half the above length, or 530ft. of wire; the deflection in this instance was 21deg.

By a reference to a trigonometrical table it will be seen that the natural tangents of 15deg. and 21deg. are very nearly in the ratio of the square roots of 1 and 2, or of the relative lengths of the wires in these two experiments.

"The length of the wire forming the galvanometer may be neglected, as it was only 8ft. long.

"*Experiment* 3.—The galvanometer was now removed, and the whole length of the wire attached to the ends of the wire of a small soft iron horse-shoe a quarter of an inch in diameter, and wound with about 8ft. of copper wire with a galvanic current from the plates used in Experiments 1 and 2. The magnetism was scarcely observable in the horse-shoe.

"*Experiment* 4.—The small plates were removed, and a battery composed of a piece of zinc plate 4in. by 7in., surrounded with copper, was substituted. When this was attached immediately to the ends of the 8ft. of wire wound round the horse-shoe, the weight lifted was 4½lb.; when the current was passed through the whole length of wire (1,060ft.), it lifted about half an ounce.

"*Experiment* 5.—The current was passed through half the length of wire (530ft.) with the same battery; it then lifted two ounces.

"*Experiment* 6.—Two wires of the same length as in the last experiment were used, so as to form two strands from the zinc and copper of the battery; in this case the weight lifted was four ounces.

"*Experiment* 7.—The whole length of the wire was attached to a small trough on Mr. Cruickshanks' plan, containing 25 double plates, and presenting exactly the same extent of zinc surface to the action of the acid, as the battery used in the last experiment. The weight lifted in this case was 8 oz.; when the intervening wire was removed, and the trough attached directly to the ends of the wire surrounding the horse-shoe, it lifted only 7oz. . . .

"It is possible that the different states of the trough, with respect to dryness, may have exerted some influence on this remarkable result; but that the effect of a current from a trough, if not increased, is but slightly diminished in passing through a long wire is certain. . . . .

"But be this as it may, the fact that the magnetic action of a current from a trough is, at least, not sensibly diminished by passing through a long wire is directly applicable to Mr. Barlow's project of forming an electro-magnetic telegraph; and it is also of material consequence in the construction of the galvanic coil. From these experiments it is evident that in forming the coil we may either use one very long wire or several shorter ones, as the circumstances may require; in the first case, our galvanic combinations must consist of a number of plates, so as to give 'projectile force;' in the second it must be formed of a single pair.

"In order to test on a large scale the truth of these preliminary results, a bar of soft iron, Fig. 5, 2in. square and 20in. long, was bent into the form of a horse-shoe, 9½in. high; the sharp edges of the bar were first a little rounded by the hammer, it weighed 21lb.; a piece of iron from the same bar, weighing 7lb., was filed perfectly flat on one surface, for an armature or lifter; the extremities of the legs of the horse-shoe were also truly ground to the surface of the armature; around this horse-shoe 540ft. of copper bell wire were wound in nine coils of 60ft. each: these coils were not continued around the whole length of the bar, but each strand of wire according to the principle before mentioned, occupied about 2in., and was coiled several times backward and forward over itself; the several ends of the wires were left projecting and all numbered, so that the first and last end of each strand might be readily distinguished. In this manner we formed an experimental magnet on a large scale, with which several combinations of wire could be made by merely uniting the different projecting ends. Thus, if the second end of the first wire be soldered to the first end of the second wire, and so on through all the series, the whole will form a continued coil of one long wire.

"By soldering different ends the whole may be formed into a double coil of half the length, or into a triple coil of one-third the

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

[33] Silliman's *American Journal of Science*, January, 1831, XIX., p. 400.

[34] "Scientific Writings of Joseph Henry," p. 39.

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length, &c. The horseshoe was suspended in a strong rectangular wooden frame, 3ft. 9in. high and 20in. wide, an iron bar was fixed below the magnet, so as to act as a lever of the second order ; the different weights supported were estimated by a sliding weight in the same manner as with a common steel-yard (*see* sketch). In the experiments immediately following (all weights being avoirdupois) a small single battery was used, consisting of two concentric copper cylinders with zinc between them ; the whole amount of zinc surface exposed to the acid from both sides of the zinc was $\frac{2}{3}$ths of a square foot ; the battery required only half a pint of dilute acid for its submersion.

"*Experiment* 8.—Each wire of the horseshoe was soldered to the battery in succession, one at a time ; the magnetism developed by each was just sufficient to support the weight of the armature weighing 7lb.

"*Experiment* 9.—Two wires, one on each side of the arch of the horseshoe, were attached ; the weight was lifted 145lb.

"*Experiment* 10.—With two wires, one from each extremity of the legs, the weight lifted was 200lb.

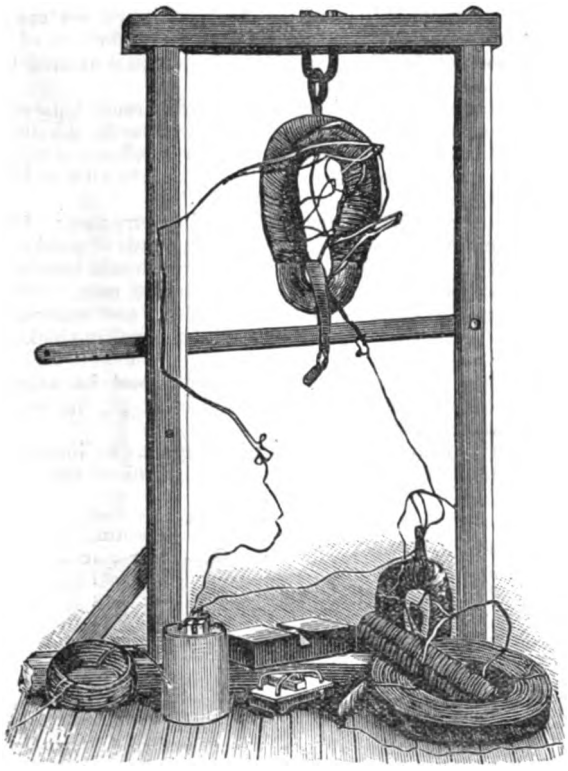

FIG. 5.—Henry's Electro-Magnet.

This figure, copied from the *Scientific American*, December 11, 1880, represents Henry's electro-magnet, still preserved in Princeton College. The other apparatus at the foot, including a current-reverser, and the ribbon-coil used in the famous experiments on secondary and tertiary currents, were mostly constructed by Henry's own hands.

"*Experiment* 11.—With three wires, one from each extremity of the legs and one from the middle of the arch, the weight supported was 300lb.

"*Experiment* 12.—With four wires, two from each extremity, the weight lifted was 500lb. and the armature ; when the acid was removed from the zinc, the magnet continued to support for a few minutes 130lb.

"*Experiment* 13.—With six wires the weight supported was 570lb. ; in all these experiments the wires were soldered to the galvanic element ; the convexion in no case was formed with mercury.

"*Experiment* 14.—When all the wires (nine in number) were attached, *the maximum weight lifted was* 650*lb.* ; and this astonishing result, it must be remembered, was produced by a battery containing only $\frac{2}{3}$rhs of a square foot of zinc surface, and requiring only half a pint of dilute acid for its submersion.

"*Experiment* 15.—A small battery, formed with a plate of zinc 12in. long and 6in. wide, and surrounded by copper, was substituted for the galvanic elements used in the last experiment ; the weight lifted in this case was 750lb.

"*Experiment* 16.—In order to ascertain the effect of a very small galvanic element on this large quantity of iron, a pair of plates, exactly 1in. square, was attached to all the wires ; the weight lifted was 85lb.

"The following experiments were made with wires of different lengths on the same horseshoe.

"*Experiment* 17.—With six wires, each 30ft. long attached to the galvanic element, the weight lifted was 375lb.

"*Experiment* 18.—The same wires used in last experiment were united so as to form three coils of 60ft. each ; the weight supported was 290lb. This result agrees nearly with that of Experiment 11, though the same individual wires were not used ; from this it appears that six short wires are more powerful than three of double the length.

"*Experiment* 19.—The wires used in Experiment 10, but united so as to form a single coil of 120ft. of wire, lifted 60lb. ; while in Experiment 10 the weight lifted was 200lb. ; this is a confirmation of the result in the last experiment. . . . .

"In these experiments a fact was observed which appears somewhat surprising ; when the large battery was attached, and the armature touching both poles of the magnet, it was capable of supporting more than 700lb., but when only one pole is in contact it did not support more than 5 or 6lb., and in this case we never succeeded in making it lift the armature (weighing 7lb.). This fact may perhaps be common to all large magnets, but we have never seen the circumstance noticed of so great a difference between a single pole and both. . . . .

"A series of experiments was separately instituted by Dr. Ten Eyck, in order to determine the maximum development of magnetism in a small quantity of soft iron.

"Most of the results given in this Paper were witnessed by Dr. L. C. Beck, and to this gentleman we are indebted for several suggestions, and particularly that of substituting cotton well waxed for silk thread, which in these investigations became a very considerable item of expense. He also made a number of experiments with iron bonnet-wires, which, being found in commerce already wound, might possibly be substituted in place of copper. The result was that with very short wire the effect was nearly the same as with copper, but in coils of long wire with a small galvanic element it was not found to answer. Dr. Beck also constructed a horseshoe of round iron 1in. in diameter, with four coils on the plan before described. With one wire it lifted 30lb., with two wires 60lb., with three wires 85lb., and with four wires 112lb. While we were engaged in these investigations, the last number of the *Edinburgh Journal of Science* was received containing Prof. Moll's Paper on 'Electro-Magnetism.' Some of his results are in a degree similar to those here described ; his object, however, was

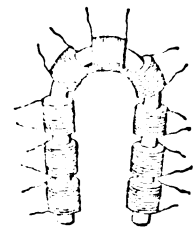

FIG. 6.—Henry's Experimental Electro-magnet.

different, it being only to induce strong magnetism on soft iron with a powerful galvanic battery. The principal object in these experiments was to produce the greatest magnetic force with the smallest quantity of galvanism. The only effect Prof. Moll's Paper has had over these investigations has been to hasten their publication ; the principle on which they were instituted was known to us nearly two years since, and at that time exhibited to the Albany Institute."[35]

In the next number of *Silliman's Journal* (April, 1831), Prof. Henry gave "an account of a large electro-magnet, made for the laboratory of Yale College." The core of the armature weighed 59½lb., it was forged under Henry's own direction, and wound by Dr. Ten Eyck. This magnet, wound with 26 strands of copper bell-wire of total length of 728ft., and excited by two cells which exposed nearly 4⅗ square feet of surface, readily supported on its armature, which weighed 23lb., a load of 2,063lb.

Writing in 1867 of his earlier experiments, Henry speaks[36] thus of his ideas respecting the use of additional coils on the magnet and the increase of battery power :—

"To test these principles on a larger scale, the experimental magnet was constructed, which is shown in Fig. 6. In this a number of compound helices was placed on the same bar, their ends left projecting, and so numbered that they could all be united into one long helix, or variously combined in sets of lesser length.

"From a series of experiments with this and other magnets, it was proved that in order to produce the greatest amount of magnetism from a battery of a single cup a number of helices is

[35] Scientific Writings of Joseph Henry, p. 49.

[36] "Statement in relation to the History of the Electro-Magnetic Telegraph :" from the Smithsonian Annual Report for 1857, p. 99.

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required; but when a compound battery is used then one long wire must be employed, making many turns around the iron, the length of wire and consequently the number of turns being commensurate with the projectile power of the battery.

"In describing the results of my experiments the terms 'intensity' and 'quantity' magnets were introduced to avoid circumlocution, and were intended to be used merely in a technical sense. By the intensity magnet I designated a piece of soft iron, so surrounded with wire that its magnetic power could be called into operation by an intensity battery; and by a quantity magnet, a piece of iron so surrounded by a number of separate coils that its magnetism could be fully developed by a quantity battery.

"I was the first to point out this connection of the two kinds of the battery with the two forms of the magnet, in my Paper, in *Silliman's Journal*, January, 1831, and clearly to state that when magnetism was to be developed by means of a compound battery one long coil must be employed, and when the maximum effect was to be produced by a single battery a number of single strands should be used. . . . Neither the electro-magnet of Sturgeon nor any electro-magnet ever made previous to my investigations was applicable to transmitting power to a distance. . . . The electro-magnet made by Sturgeon, and copied by Dana, of New York, was an imperfect quantity magnet, the feeble power of which was developed by a single battery."

Finally, Henry[37] sums up his own position as follows:—

"1. Previous to my investigations the means of developing magnetism in soft iron were imperfectly understood, and the electro-magnet which then existed was inapplicable to transmissions of power to a distance.

"2. I was the first to prove by actual experiment that in order to develop magnetic power at a distance, a galvanic battery of 'intensity' must be employed to project the current through the long conductor, and that a magnet surrounded by many turns of one long wire must be used to receive this current.

"3. I was the first to actually magnetise a piece of iron at a distance, and to call attention to the fact of the applicability of my experiments to the telegraph.

"4. I was the first to actually sound a bell at a distance by means of the electro-magnet.

"5. The principles I had developed were applied by Dr. Gale to render Morse's machine effective at a distance."

Though Henry's researches were published in 1831, they were for some years almost unknown in Europe. Until April, 1837, when Henry himself visited Wheatstone at his laboratory at King's College, the latter did not know how to construct an electro-magnet that could be worked through a long wire circuit. Cooke, who became the coadjutor of Wheatstone, had originally come to him to consult him,[38] in February, 1837, about his telegraph and alarum, the electro-magnets of which, though they worked well on short-circuits, refused to work when placed in circuit with even a single mile of wire. Wheatstone's own account[39] of the matter is extremely explicit:—"Relying on my former experience, I at once told Mr. Cooke that his plan would not and could not act as a telegraph, because sufficient attractive power could not be imparted to an electro-magnet interposed in a long circuit; and to convince him of the truth of this assertion, I invited him to King's College to see the repetition of the experiments on which my conclusion was founded. He came, and after seeing a variety of voltaic magnets, which even with powerful batteries exhibited only slight adhesive attraction, he expressed his disappointment."

After Henry's visit to Wheatstone, the latter altered his tone. He had been using, *faute de mieux*, relay circuits to work the electro-magnets of his alarum in a short circuit with a local battery. "These short circuits," he writes, "have lost nearly all their importance, and are scarcely worth contending about since *my discovery*" (the italics are our own) "that electro-magnets may be so constructed as to produce the required effects by means of the direct current, even in very long circuits."[40]

We pass on to the researches of the distinguished physicist of Manchester, whose decease we have lately had to deplore, Mr. Joule, who, fired by the work of Sturgeon, made most valuable contributions to the subject. Most of these were published either in Sturgeon's "Annals of Electricity," or in the "Proceedings of the Literary and Philosophical Society of Manchester," but their most accessible form is the republished volume issued five years ago by the Physical Society of London.

In his earliest investigations he was endeavouring to work out the details of an electric motor. The following is an extract from his own account ("Reprint of Scientific Papers," p. 7):—

"In the further prosecution of my inquiries, I took six pieces of round bar iron of different diameters and lengths, also a hollow cylinder, $\frac{1}{13}$th of an inch thick in the metal. These were bent in the U-form, so that the shortest distance between the poles of each was half an inch; each was then wound with 10ft. of covered copper wire, $\frac{1}{40}$th of an inch in diameter. Their attractive powers under like currents for a straight steel magnet, 1½in. long, suspended horizontally to the beam of a balance, were, at the distance of half an inch, as follows:—

	No. 1. Hollow	No. 2. Solid.	No. 3. Solid.	No. 4. Solid.	No. 5. Solid.	No. 6. Solid	No. 7. Solid.
Length round the bend in inches.....	6	5½	2⅜	5¼	2½	5¼	2½
Diameter in inches...	½	½	½	⅜	⅜	¼	¼
Attraction for steel magnet, in grains	7·5	6·3	5·1	5·0	4·1	4·8	3·6
Weight lifted, in ounces	36	52	92	35	52	20	28

"A steel magnet gave an attractive power of 23 grains, while its lifting-power was not greater than 60oz.

"The above results will not appear surprising if we consider, first, the resistance which iron presents to the induction of magnetism, and, second, how very much the induction is exalted by the completion of the magnetic circuit.

"Nothing can be more striking than the difference between the ratios of lifting to attractive power at a distance in the different magnets. Whilst the steel magnet attracts with a force of 23 grains and lifts 60oz., the electro-magnet No. 3 attracts with a force of only 5·1 grains, but lifts as much as 92oz.

"To make a good electro magnet for lifting purposes:—1st. Its iron, if of considerable bulk, should be compound, of good quality and well annealed. 2nd. The bulk of the iron should bear a much greater ratio to its length than is generally the case. 3rd. The poles should be ground quite true, and fit flatly and accurately to the armature. 4th. The armature should be equal in thickness to the iron of the magnet.

"In studying what form of electro-magnet is best for attraction from a distance, two things must be considered, viz., the length of the iron, and its sectional area.

"Now I have always found it disadvantageous to increase the length beyond what is needful for the winding of the covered wire."

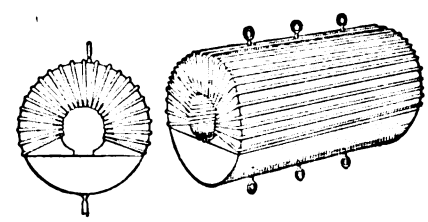

FIG. 7.—Joule's Electro-Magnet.

These results were announced in March, 1839. In May of the same year he propounded a law of the mutual attraction of two electro-magnets, as follows:—"The attractive force of two electro-magnets for one another is directly proportional to the square of the electric force to which the iron is exposed; or if E denote the electric current, W the length of wire, and M the magnetic attraction, $M = E^2 W^2$." The discrepancies which he himself observed he rightly attributed to the iron becoming saturated magnetically. In March, 1840, he extended this same law to the lifting power of the horse-shoe electro-magnet.

In August, 1840, he wrote to the "Annals of Electricity," on electro-magnetic forces, dealing chiefly with some special electro-magnets for traction. One of these possessed the form shown in Fig. 7. Both the magnet and the iron keeper were furnished with eye-holes for the purpose of suspension and measurement of the force requisite to detach the keeper. Joule thus writes about the experiments.[41]

"I proceed now to describe my electro-magnets, which I constructed of very different sizes in order to develop any curious circumstance which might present itself. A piece of cylindrical wrought iron 8in. long, had a hole 1in. in diameter, bored the whole length of its axis; one side was planed until the hole was exposed sufficiently to separate the thus-formed poles one-third of an inch. Another piece of iron, also 8in. long, was then planed, and being secured with its face in contact with the other planed surface, the whole was turned into a cylinder 8in. long, 3¾in. in exterior, and 1in. interior diameter. The larger piece was then covered with calico and wound with four copper wires covered with

[37] "Scientific Writings of Joseph Henry," Vol. II., p. 435.

[38] *See* Mr. Latimer Clarke's account of Cooke in Vol. VIII. of *Journal* of Society of Telegraph-Engineers, p. 374.

[39] W. F. Cooke, "The Electric Telegraph; was it Invented by Professor Wheatstone?" 1855-7, part II., p. 87.

[40] *Ib.*, p. 95.

[41] "Scientific Papers," Vol. I., p. 30.

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silk, each 23ft. long, and $\frac{1}{11}$th of an inch in diameter—a quantity just sufficient to hide the exterior surface, and to fill the interior opened hole." . . . . "The above is designated No. 1; and the rest are numbered in the order of their description.

"I made No. 2 of a bar of half-inch round iron 2·7in. long. It was bent into an almost semi-circular shape, and then covered with 7ft. of insulated copper wire, 1-20th of an inch thick. The poles are half-an-inch asunder; and the wire completely fills the space between them.

"A third electro-magnet was made of a piece of iron 0·7in. long, 0·37in. broad, and 0·15in. thick. Its edges were reduced to such an extent that the transverse section was elliptical. It was bent into a semicircular shape, and wound with 19in. of silked copper wire, 1-40th of an inch in diameter.

"To procure a still more extensive variety, I constructed what might, from its extreme minuteness, be termed an elementary electro-magnet. It is the smallest, I believe, ever made, consisting of a bit of iron wire $\frac{1}{4}$ of an inch long, and 1-25th of an inch in diameter. It was bent into the shape of a semicircle, and was wound with three turns of uninsulated copper wire 1-40th of an inch in thickness."

With these magnets experiments were made with various strengths of currents, the tractive forces being measured by an arrangement of levers. The results, briefly, are as follows:—Electro-magnet No. 1, the iron of which weighed 15lbs., required a weight of 2,090lbs. to detach the keeper. No. 2, the iron of which weighed 1,057 grains, required 49.bs. to detach its armature. No. 3, the iron of which weighed 65·3 grains, supported a load of 12lbs., or 1,286 times its own weight. No. 4, the weight of which was only half a grain, carried in one instance 1,417 grains, or 2,834 times its own weight.

"It required much patience to work with an arrangement so minute as this last; and it is probable that I might ultimately have obtained a larger figure than the above, which, however, exhibits a power proportioned to its weight far greater than any on record, and is 11 times that of the celebrated steel magnet which belonged to Sir Isaac Newton.

"It is well known that a steel magnet ought to have a much greater length than breadth or thickness; and Mr. Scoresby has found that when a large number of straight steel magnets are bundled together, the power of each when separated and examined is greatly deteriorated. All this is easily understood, and finds its cause in the attempt of each part of the system to induce upon the other part a contrary magnetism to its own. Still there is no reason why the principle should in all cases be extended from the steel to the electro-magnet, since in the latter case a great and commanding inductive power is brought into play to sustain what the former has to support by its own unassisted retentive property. All the preceding experiments support this position; and the following table gives proof of the obvious and necessary general consequence, the maximum power of the electro-magnet is directly proportional to its least transverse sectional area. The second column of the table contains the least sectional area in square inches of the entire magnetic circuit. The maximum power in pounds avoirdupois is recorded in the third; and this, reduced to an inch square of sectional area, is given in the fourth column under the title of specific power."

Table I.

Description.	Least sectional area.	Maximum power.	Specific power.
My own electro-magnets (No. 1 . .....)	10	2090	209
(No. 2 .....)	0·196	49	250
(No. 3 .....)	0·0436	12	275
(No. 4 .....)	0·0012	0·202	162
Mr. J. C. Nesbit's. Length round the curve, 3ft.; diameter of iron core, 2⅞in.; sectional area, 5·7in.; do. of armature, 4·5in.; weight of iron, about 50lb.	4·5	1428	317
Prof. Henry's. Length round the curve, 20in.; section, 2in. square; sharp edges rounded off; weight, 21lb.	3·94	750	190
Mr. Sturgeon's original. Length round the curve, about 1ft.; diameter of the round bar, ½in.	0·195	50	255

"The above examples are, I think, sufficient to prove the rule I have advanced. No. 1 was probably not fully saturated; otherwise I have no doubt that its power per square inch would have approached 300. Also, the specific power of No. 4 is small, because of the difficulty of making a good experiment with it."

These experiments were followed by some to ascertain the effect of the length of the iron of the magnet, which he considered, at least in those cases where the degree of magnetisation is considerably below the point of saturation, to offer a decidedly proportional resistance to magnetisation; a view the justice of which is now after fifty years amply confirmed.

In November of the same year further experiments[42] in the same direction were published. A tube of iron, spirally made and welded, was prepared, planed down as in the preceding case, and fitted to a similarly prepared armature. The hollow cylinder thus formed, shown in Fig. 8, was 2·t. in length, its internal diameter was 1·42in., its internal being 0·5in. The least sectional area was 10¼ square in. The exciting coil consisted of a single copper rod, covered with tape, bent into a sort of S-shape. This was later replaced by a coil of 21 copper wires, each 1·25in. in diameter and 23ft. long, bound together by cotton tape. This magnet, excited by a battery of 16 of Sturgeon's cast-iron cells, each 1ft. square and 1½in. in interior width, arranged in a series of four, gave a lifting power of 2,775lbs.

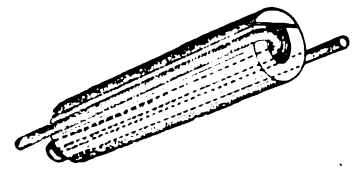

Fig. 8.—Joule's Cylindrical Electro-Magnet.

Joule's work was well worthy of the master from whom he had learned his first lesson in electro-magnetism. He showed his devotion not only by writing descriptions of them for Sturgeon's "Annals," but by exhibiting two of his electro-magnets at the Victoria Gallery of Practical Science, of which Sturgeon was director. Others, stimulated into activity by Joule's example, proposed new forms, amongst them being two Manchester gentlemen, Mr. Radford and Mr. Richard Roberts, the latter being a well-known engineer and inventor. Mr. Radford's electro-magnet consisted of a flat iron disc, with deep spiral grooves cut in its face, in which were laid the insulated copper wires. The armature consisted of a plain iron disc of similar size. This form is described in Vol. IV. of Sturgeon's "Annals."

Mr. Roberts's form of electro-magnet consisted of a rectangular iron block, having straight parallel grooves cut across its face, as in Fig. 9. This was described in Vol. VI. of Sturgeon's "Annals," p. 166. Its face was 6§ inches square, and its thickness 2$\frac{7}{8}$ inch. It weighed, with the conducting wire, 35lbs.; and the armature, of the same size and 1½in. thick, weighed 23lbs. The load sustained by this magnet was no less than 2,950lbs. Roberts inferred that a magnet if made of equal thickness, but 5ft. square, would sustain 100 tons weight. Some of Roberts's apparatus is still preserved in the Museum of Peel Park, Manchester.

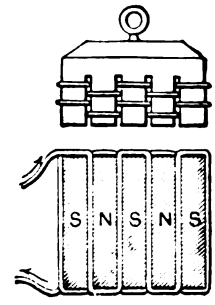

Fig. 9.—Roberts's Electro-Magnet.

On p. 431 of the same volume of the "Annals," Joule described yet another form of electro-magnet, the form of which resembled in general Fig. 10; but which, in actual fact, was built up of 24 separate flat pieces of iron bolted to a circular brass ring. The armature was a similar structure, but not wound with iron. The iron of the magnet weighed 7lbs., and that of the armature 4·55lbs. The weight was 2,710lbs., when excited by 16 of Sturgeon's cast-iron cells.

In a subsequent Paper on the calorific effects of magneto-electricity,[43] published in 1843, Joule described another form of electro-magnet of horse-shoe shape, made from a piece of boiler-plate. This was not intended to give great lifting power, and was used as the field-magnet of a motor. In 1852, another powerful electro-magnet of horse-shoe form, somewhat similar to the preceding, was constructed by Joule for experiment. He came to the conclusion[44]

[42] "Scientific Papers," p. 40, and "Annals of Electricity," Vol. V., p. 170

[43] "Scientific Papers," Vol. I., p. 123; and *Phil. Mag.*, Ser. 3, Vol XXIII., p. 263, 1843.

[44] "Scientific Papers," Vol. I., p. 362; and *Phil. Mag.*, Ser. 4, Vol. III. p. 32

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that, owing to magnetic saturation setting in, it was improbable that any force of electric current could give a magnetic attraction greater than 200lbs. per square inch. "That is, the greatest weight which could be lifted by an electro-magnet formed of a bar of iron 1in. square, bent into a semi-circular shape, would not exceed 400lbs."

With the researches of Joule may be said to end the first stage of development. The notion of the magnetic circuit which had thus guided Joule's work did not commend itself at that time to the professors of physical theories; and the practical men, the telegraph engineers, were for the most part content to work by purely empirical methods. Between the practical man and the theoretical man there was, at least on this topic, a great gulf fixed. The theoretical man, arguing as though magnetism consisted in a

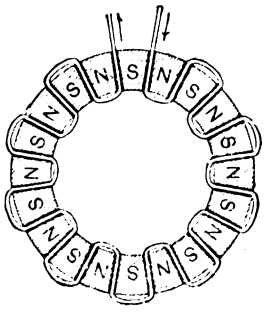

FIG. 10.—Joule's Zig-zag Electro-Magnet.

surface distribution of polarity, and as though the laws of electro-magnets were like those of steel magnets, laid down rules not applicable to the cases which occur in practice, and which hindered rather than helped progress. The practical man, finding no help from theory, threw it on one side as misleading and useless. It is true that a few workers made careful observations and formulated into rules the results of their investigations. Amongst these the principal were Ritchie, Robinson, Müller, Dub, Von Kolke, and Du Moncel; but their work was little known beyond the pages of the scientific journals wherein their results were described. Some of these results will be examined in my later lectures, but they cannot be discussed in this historical *résumé*, which is accordingly closed.

(To be continued.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 5, 1890.

The Street Railway Organisations and Electric Propulsion.—A striking sign of the times is the great interest taken in electricity by all the street railway organisations. On September 16th, the New York Street Railway Association is to meet in Rochester, and it announces that a large part of the time of the Association will be devoted to the consideration of electrical propulsion. Representatives of all the leading electrical systems will be present, and in all probability foundations will be there laid for some increase of electrical traction. The American Street Railway Association, which is the general organisation in this country, meets October 15th, 16th, and 17th, at Buffalo, New York, and, like the smaller organisation, a considerable part of the interest of the meeting will centre on reports of electrical progress. Several important electrical Papers will be read at that time, and it is probable that the discussion will not be so much upon the possibilities of improvement in the other forms of motive power as in the most expeditious means of getting rid of them and adopting electric power. Among other bits of railway news, I may mention that a 25-mile electric road, running out of the city of Buffalo, through intervening towns to Niagara Falls, is projected, and work will probably soon be begun. It will be operated by a single-power station, and in all probability some attempt will be made to introduce higher speeds than present practice admits.

A Primary Battery Mania.—We are having just now an epidemic of primary battery fever. Three or four new companies of inconsiderable size and small influence have recently been started in various parts of the country, and there are distressing symptoms of more to follow. The unfortunate part of the business is that a considerable amount of money is wheedled out of innocent investors, and in addition some harm is done to electrical interests in general, since the oft-swindled public gradually grows suspicious of everything electrical. One of the most extraordinary of these schemes proposes to work wonders through the medium of a storage battery to be charged from a primary battery.

A New Thermopile.—It transpires that the discovery of a means of producing electricity direct from heat, reported from Hartford, Connecticut, some weeks since, and about which there was so much talk, is nothing more nor less than a glorified thermopile, with presumably the inefficiency and other disadvantages that pertain to that venerable apparatus.

Meeting of the National Telephone Convention.—The National Telephone Convention meets next week at Detroit, Michigan, and in all probability the proceedings will be of unusual interest. Last year there was special activity shown in the matter of all metallic circuits, long-distance telephony, and the like, and appearances indicate that still further improvements will be shown at the present meeting. The subject of induction interferences between telephone and electric light and power lines will probably come up for vigorous discussion, although the details of any proceedings taken on this subject may not be made public. The legal decisions in the cases that have been brought to an issue in this country have been pretty uniformly against the telephone companies, although not often relieving the interfering lines from responsibility, and with the increase in electric railroading, this question becomes more and more important.

CORRESPONDENCE.

THE ELECTRIC LIGHT AT BATH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue I noticed a letter from Charles Powell, who has imposed upon you by stating that he "recently had a run down to Bath," and that he "met the police going to the station to report lamps out, and went with them," &c. Charles Powell was actually in my employ for a month as an engine driver, and was summarily discharged by me for savagely assaulting the second engineer, who had upbraided him for his negligence, which resulted in a breakdown and temporary extinguishment of the lights. Your contemporaries have been imposed upon by the same person, and published similar information; but, unlike yourselves, they did not give the name of their informant, and had it not been for your doing this I should have been unable to expose the matter.

I may mention that when he was leaving here, he intimated to my staff that he would have his revenge for being dismissed, hence his communications to the technical press.—Yours, &c.,

Bath Electric Light Works, H. G. MASSINGHAM.
Bath, September 15, 1890.

MAGNET STEEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I see Mr. Preece is complaining once more of the sad deterioration in the magnet steel of English makers. He cannot obtain an induction over 2,000 gausses, it seems. May I once more state that both Messrs. Jowitt and Mr. J. P. Wall supply steel which, when properly treated, has a permanent induction of over 4,000 gausses. We make a large number of magnets from Wall steel for use in our portable generators, and have no difficulty whatever in getting a permanent induction of from 4,000 to 5,000 gausses. In fact, no magnet of our own make has given less than 3,700 gausses. The secret of success lies in properly hardening the steel, and I have no doubt our smith would be happy to show Mr. Preece how it is done.—Yours, &c., SYDNEY EVERSHED.

Buxton, September 17, 1890.

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MAGNETIC BRASS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with interest your note in last week's *Electrician* respecting magnetic brass, as I had some trouble from the decidedly magnetic properties of the brass bobbins used for the current coil of my ohm meter. In the first astatic instrument we made these bobbins were cast in one piece, and the needles were strongly attracted to the edges of the bobbin cheeks. I naturally looked for flats on the pivot or the point of the axle, or a crack in the jewel-cup, and only after investigating every impossible and apparently possible cause in vain, did it occur to me that the brass was magnetic. However, on replacing the castings by bobbins of rolled brass the defect vanished. I found a small bar of metal cut from one of the delinquent castings was strongly magnetic, although it showed no trace of polarity.

In an experimental instrument I had previously noticed apparent magnetic permeability in a *rolled brass* frame closely surrounding an astatic system of needles, so that it is necessary to examine all brass before putting it into sensitive instruments.—Yours, &c., SYDNEY EVERSHED.

Buxton, 17th September, 1890.

COMPARING CAPACITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think Dr. Muirhead's Inductive Capacity Test (see *The Electrician*, September 5th), using a Saunders' key, a splendid one, and the key is certainly a "long-felt want supplied." The test will recommend itself as an efficient check on the ordinary methods of testing. The times of charging are *very* wide, but the result shows up the beauties of the test. In Table I., a little under two seconds; and for the cable, two seconds appeared to be the best times for application of the particular currents used.

I would ask how the true capacity of the cable was arrived at, because if it is the factory test, the figures given in the table would represent *about* the true capacity of the cable when laid, as the effects of pressure and temperature must then be taken into account.—Yours, &c., H. CASENHEM.

MORLEY MEMORIAL COLLEGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I call the attention of your readers to the advertisement on page xvii. of this paper? We are anxious to make known these classes to heads of firms, that they may facilitate their *employés* joining them; that more people may be benefited by the higher education now placed within the reach of all who wish to improve themselves. You will notice that the classes are not exactly free, because we do not desire to pauperise our working friends, not even with education, and being sure that they would prefer to pay part of the expenses; but the fees are so small that it places education within the reach of the *very poorest*, so that none can in future years say that they wished to educate themselves but could not afford to do so. Last year our numbers rose to over 800. We have room for 1,000 students, and hope this year to have that number as the College becomes more known.

Thanking you for your kindness in helping our work, I am, yours, &c., EMMA CONS, Hon. Sec. and Trustee.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

BELFAST.—The Corporation are endeavouring to obtain the sanction of the Local Government Board to borrow £50,000 for electric lighting purposes.

VACANT APPOINTMENT.—The Jamaica Institute, Kingston, Jamaica, require a secretary and librarian, who shall not be a member of the Civil Service. He must be competent to perform the duties set out in the printed conditions—amongst which is the encouragement of literature, science, and art in the island. The salary is £500 per annum. Applications must be accompanied by testimonials, and reach the Secretary of the Institute by November 30th next, from whom printed conditions can be obtained on application.

MESSRS. W. SOUTTER AND SONS.—We have received from this old-established firm of art metal workers an elaborate catalogue of very artistic designs for electric light brackets, electroliers, pendants, ceiling lights, wall mirrors, table lamps, bell pushes, bells, and switches, &c. On the frontispiece of the catalogue (which is large folio book) is an engraving of the very large works of the Company at Birmingham. Many of the designs in the book show great taste. Amongst the brackets may be mentioned Nos. 1665, 1670, 1764, 1506, 1524, 421, 1587, 1581, 1507, 1520, 1641, 1648, and 1635. No. 1666 is a three-light passion-flower electrolier, and is a very chaste design. The ceiling lights and wall mirrors are cheap and worthy of notice, and include an excellent selection. The catalogue is well got up, and reflects credit both on compiler and printer.

"ELECTRICITY IN EVERY-DAY LIFE."—With reference to our note of last week, respecting the issue of a brochure by Messrs. Goolden and Co., we understand that this is issued for private circulation only, and not for sale. A similar book will, however, be issued shortly for public sale.

WOODHOUSE AND RAWSON UNITED (LIMITED).—We are in receipt of some well-got-up circulars from this Company, giving illustrated particulars of Lincrusta-Walton bell pushes, specially designed for use on the Lincrusta-Walton paper, the diamond waste oil filter, electric bell dry battery, and a card list of prices of Hardtmuth's electric light carbons, for which the Woodhouse and Rawson Company are agents.

MR. SCHMIDT.—We are in receipt of an illustrated circular giving the prices and particulars of The Instantaneous and Continuous Screw Vice, made by Mr. Schmidt.

MESSRS. HOLDEN AND BROOKE (LIMITED).—We have to acknowledge the receipt of a large quarto catalogue, containing 100 pages of descriptive matter, and prices of injectors and fittings made by this firm. A large number of illustrations are given, and the catalogue contains some useful tables. Flattering testimonials from a large number of users of Messrs. Holden and Brooke's manufactures are set out; amongst the users being a large number of electrical firms. On page 28 sectional drawings are given, showing the arrangement of the high-speed electric light engines, and the automatic and supplementary injector. The catalogue is admirably arranged and well printed.

MESSRS. MARSHALL, SONS AND COMPANY.—This firm have been awarded six separate highest awards for their engines, boilers, saw-bench, &c., exhibited at the New Zealand International Exhibition this year.

THE NEW YORK INSULATED WIRE COMPANY.—This Company send us their new price list (No. 17, August, 1890), which gives particulars and prices of "Grimshaw" Cables, Wire and Tapes. Wright, gauge and resistance tables are included, and the book is a handy size for the pocket.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

August 16, 1890.

12,874. C. R. BONNE. London. Improved electric switch. (The Actien Gesellschaft, Mix and Genest, Germany.)

August 18, 1890.

12,914. A. J. JARMAN. London. Improvements in switches for controlling and regulating double or compound electric motors, especially applicable to traction or marine propulsion.

12,915. A. J. JARMAN. London. Improvements in brush holders for dynamo-electric motors and generators.

12,957. D. H. DAVIES and J. M. TOURTEL. London. Improvements in electric lighting by means of coin feed apparatus.

12,958. D. H. DAVIES and J. M. TOURTEL. London. Improvements in apparatus for effecting by insertion of a coin the production of electric light for a certain time.

August 19, 1890.

12,979. H. B. COX. London. Improvements in thermo-electric generators.

12,997. W. B. BRAIN, A. J. ARNOT, and F. BAKER. London. An improved electrical rock-drill coal digger or earth cutter.

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13,002. H. H. Lake. London. Improvements relating to induction coils or transformers chiefly designed for use in welding or otherwise working metal by electricity (E. Thomson, United States).

13,003. D. Pepper, jun. London. Improvements in the manufacture of electrodes for primary and secondary batteries.

13,006. H. H. Lake. London. Improvements in welding or otherwise working metals by electricity and in apparatus therefor (E. Thomson, United States).

13,013. D. Pepper, jun. London. Improvements in the manufacture of electrodes for primary and secondary batteries.

13,024. G. O. Rennerfelt. London. Method of, and apparatus for, producing by means of electrolysis decomposed products of melted haloid salts, and other combinations of metals.

13,042. C. J. Van Depoele. Liverpool. Improvements in or appertaining to electric railway systems.

13,044. P. E. Bardonnant and P. Jupfont. Liverpool. A new or improved method and apparatus for effecting economy of electric force in electric writing. (Date applied for under Patents Act, 1883, Sec. 103, 20th February, 1890, being date of application in France.)

13,049. F. E. Macmahon. London. Improvements in electric telegraphs in part applicable for signalling on racecourses and elsewhere.

August 20, 1890.

13,107. K. Kurmayer, S. Cappilleri, H. Grunwald, and C. Holzappel. London. Improvements in electric arc lamps.

August 21, 1890.

12,123. G. Hookham. Birmingham. Improvements in electricity meters for alternating or interrupted currents.

13,129. A. W. Slater. Blackheath. Improvements in safety fuses or cut-outs for electrical circuits.

13,161. A. Lucas and E. Sundboig. London. Improvements in means and apparatus for adjusting electric suspending lights and for other like purposes.

13,171. L. Hoepl and E. Courtin. London. Improvements in fittings for incan lescent electric lamps.

13,175. W. Peto. London. Improvements in miners' electric safety lamps.

13,187. R. F. Moore. London. Improvements in electro-motors.

August 22, 1890.

13,190. R. Kennedy. Kilmarnock. Improvements in exciting electro magnets and electro-magnetic machinery.

13,199. J. Graham. London. Improvements in electric telephone switch apparatus.

13,212. R. Drysdale. Birm'ngham. Improvements in electric accumulators.

13,223. The Mining and General Electric Lamp Company, Limited, and W. Moscrop. London. Improvements in portable electric lamps, more especially intended for miners' use.

13,256. J. T. Gent, A. W. Staveley and I. H. Parsons. Improvements in coin-freed electrical apparatus.

13,260. M. von Dolivo, Dobrowolsky and P. Mamroth. Trading as Allgemeine Electricitäts Gesellschaft. London. Improved means for the distribution of electricity.

SPECIFICATIONS PUBLISHED.

1889.

7,005. Schanschieff. Galvanic batteries. (Price 6d.)

10,640. Crampton and Essinger. Electric arc lamps. (Price 8d.)

12,185. Howard. Distributing electricity. (Price 11d.)

12,236. Swinburne. Alternating, &c. electric currents. (Price 8d.)

12,237. Swinburne. Electric transformer. (Price 8d.)

12,389. Houghton. Electrical contact maker, &c. (Price 6d.)

12,563. Lowne. Electrical ships' logs. (Price 11d.)

13,154. Mather and Sumpner. Constructing electrical coils. (Price 6d.)

13,273. Julian. Arc lamps. (Price 6d.)

13,553. Edwards (Perls). Electric railway signalling apparatus. (Price 8d.)

14,011. Shepard. Opening, &c., electrical circuits. (Price 8d.)

14,366. Boult. Arc lamps. (Price 8d.)

14,377. Bradford. Electric lighting circuits. (Price 1s. 1d.)

14,464. Batault. Electricity meters. (Price 8d.)

14,590. Groves and Stewart. Electric bells. (Price 8d.)

14,971. Dujardin. Secondary batteries. (Price 6d.)

15,230. Vavasour. Electric batteries. (Price 1s. 8d.)

15,246. Lahmeyer. Regulating motor dynamos, &c. (Price 8d.)

15,402. Thompson (Westinghouse). Electric distribution. (Price 8d.)

15,503. Andersen. Dynamo-electric machines. (Price 8d.)

15,567. Kincaid and Others. Propelling vehicles by electricity. (Price 4d.

15,769. Thomson. Electric currents. (Price 11d.)

15,936. Robson. Cleaning electric lamps. (Price 8d.)

15,968. Johnson and Phillips. Electric conductors. (Price 6d.)

15,974. Blackmore. Electric arc lamps. (Price 8d.)

16,585. Marcher and Ernecke. Electric switches. (Price 8d.)

16,680. Chambers. Attaching telpher cables, &c., to insulators (Price 8d.)

16,697. Bláthy. Electro-dynamic machines. (Price 11d.)

17,060. Parker. Electrical furnaces. (Price 8d.)

17,236. Heyl. Electric cables. (Price 8d.)

18,980. Bradner. Suspending electric lamps. (Price 8d.)

20,797. Strode and Gill. Electric light fittings. (Price 8d.)

1890.

3,731. The Mining and General Electric Lamp Company (Limited) and Fitzgerald. Secondary batteries. (Price 4d.)

7,988. Coffin. Welding metal electrically. (Price 6d.)

7,989. Coffin. Welding metal by electricity. (Price 6d.)

7,990. Coffin. Electric welding. (Price 6d.)

7,991. Coffin. Electric welding. (Price 6d.)

7,992. Coffin. Electric welding. (Price 6d.)

7,993. Coffin. Welding metals electrically. (Price 6d.)

7,994. Coffin. Welding metals electrically. (Price 8d.)

8,241. Jeffers. Electric lamp hangers. (Price 8d.)

8,777. Lake (Hathaway). Electric call bells. (Price 8d.)

8,778. Groswith. Electric motors. (Price 8d.)

9,796. Gill. Electric circuit controlling apparatus. (Price 8d.)

9,857. Dewey. Welding, &c., metals by electricity. (Price 8d.)

10,134. Johnson (Cheever). Electric cables, &c. (Price 4d.)

10,181. Foote. Secondary batteries. (Price 8d.)

10,515. Jarman. Electrical batteries. (Price 6d.)

10,564. Scott. Printing telegraphs. (Price 6d.)

10,593. Currie. Electric motor apparatus. (Price 8d.)

10,712. Nichols. Electric lamp couplers. (Price 6d.)

11,061. Swart. Electric railway switches. (Price 6d.)

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

ROLLED AND DRAWN

PHOSPHOR BRONZE.

PHOSPHOR BRONZE

BEARINGS, BUSHES,

AND OTHER PARTS OF

ELECTRICAL MACHINERY.

SOLE PROPRIETORS of the British, Indian and Colonial Patents,

THE PHOSPHOR BRONZE COMPANY (Limited),

87, Sumner Street, Southwark, London, S.E.

WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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NEW COMPANIES REGISTERED.

GLASGOW AND DISTRICT PULSION TELEPHONE COMPANY.—Registered in Scotland with a capital of £6,100, in 6,000 ordinary shares of £1 and 100 founders' shares. Object: To acquire and make binding upon the company, and to carry into effect, an agreement dated July 2 last, made between the Primary Syndicate (Limited), of 72, King William-street, London, and James Weir Cathcart, of 51, Pall-mall, London, on behalf of this Company, and to accept and execute the licences referred to in that agreement; to purchase or otherwise acquire any patents or patent rights or licences or any invention comprised in or referred to in said agreement, and any invention analogous to or capable of being used in connection with the invention, or which the Company may consider desirable to obtain for the purposes of its business in respect of any such invention, and any trade marks, registered designs, or such other privileges as the Company may deem expedient: to experiment with, exhibit and use, work and turn to account any inventions, licences or privileges acquired by the Company within the counties of Lanark, Renfrew, Stirling, and Dumbarton, as may be found expedient. The Directors shall not be less than three nor more than five in number, and the first Board shall be appointed by the subscribers to the memorandum of agreement and Articles of Association of the Company.

NORTH BRITISH BOILER AND MACHINERY INSURANCE COMPANY.—Capital, £75,000, in £1 shares. Objects, to insure against damage arising from explosion of steam boilers and the breaking down of steam engines, with the buildings and machinery of the works in which these are set, the policy of the Company covering loss of every description to the extent insured; to periodically inspect and report on the condition of steam boilers and steam engines, and advise as to their management, and as to the most recent developments of engineering science; to advise as to boilers, engines, and other engineering structures; surveying the manufacturing of all kinds of plant having relation to, or required in, engineering structures comprising the testing of the various metals used in connection therewith; to carry on the business of general consulting engineers in all its branches, to insure employers against claims made against them at the instance of their *employés* under the Employers' Liability Act and at common law; to purchase the goodwill or any interest of any trade or business of the same nature; to carry on the business of engineers and boiler-makers and repairers of engines and boilers. Directors not to be less than three nor more than eight in number. The first Directors are to be Ralph Moore, C. and M.E., Glasgow; Bailie Robert Sharp, iron and steel merchant, Coatbridge; Robert Clark, Armiston Coal Company, Gorebridge; Robert Highgate, of Pollok, Nitrab and Highgate, Firpark Iron Works, Shettleston, Glasgow, and Britannia Iron Works, Manchester; J. C. Adamson, J.P., Airdrie Iron Company, Airdrie; and Prof. Alexander MacLay, B.Sc., C.E., Glasgow and West of Scotland Technical College.

WHITFIELD, HODGSONS AND BROUGH (LIMITED).—Capital £10,000, in £10 shares. Object, to acquire the business of Charles Whitfield, mechanical engineer, of the Union-street Ironworks, Kettering. Not less than three nor more than four Directors. The first are C. Whitfield, J. E. Hodgson, T. E. P. Hodgson, and W. P. Brough.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 12th amounted to £4,728.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The Board derided on Wednesday to recommend the payment of the dividend at the rate of 10 per cent. on the Preference Shares, and a dividend at the rate of 6 per cent. (free of income-tax) upon the ordinary shares for the half-year ended June 30th last. The Report of the Directors will be issued this day (Friday).

ELMORE'S FRENCH PATENT COPPER DEPOSITING COMPANY (LIMITED).—The prospectus of this Company was issued on Saturday last. The Company has a capital of £200,000, in 100,000 shares of £2 each, of which 66,750 shares were offered for subscription at a premium of 10s. per share. Of the 100,000 shares, 13,000 shares were applied for by the Directors and their friends. The Directors are Sir Richard J. Meade, K.C.S.I., C.I.E. (chairman), Major Charles Jones (vice-chairman), Mr. E. J. Carson, Mr. William Elmore, Mr. Charles Glendining Philips, and Sir J. D. Mackenzie, Bart. (Managing Director). The consulting metallurgical chemists are Francis E. Elmore, Esq., and Alexander S. Elmore, Esq.; and the secretary is Mr. James Shurmer. The Works are situate at Bellegarde, near Lyons, and the London office is at 20, Bucklersbury, E.C. This Company is formed to acquire the patents for France (numbered 192,985, of 1888, and 195,277, of 1889) relating to the discovery made by Messrs. F. E. Elmore and A. S. Elmore, for manufacturing, amongst other things, copper articles direct from rough copper bars. The patents are sold to this Company by Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited) for £83,500 payable in cash, and £66,500 payable in shares, together with the premiums received from the issue of the shares now offered for subscription, the vendors paying all preliminary expenses up to the first allotment of shares. No founders' shares are created. After completion of the above purchase there will remain the sum of £50,000 for working capital. The lists opened and closed on Tuesday last. The Memorandum of Association is a very exhaustive one, under which the Company has power to undertake an extremely varied assortment of businesses, including those of bankers and financial agents.

FIVE PER CENT.—The *Financial News* of yesterday contained an interesting article on the subject of investments yielding 5 per cent. Included in the list by our contemporary are "The Globe Telegraph and Trust Company, Limited," "The Anglo-American Telegraph Preference," and "The Direct Spanish Telegraph Preference," yielding 5¼, 6¼, and 5¼ per cent. respectively, at the prices of 8⅞, 88, and 92.

GENERAL ELECTRIC POWER AND TRACTION COMPANY.—The statutory general meeting of this Company will be held at Winchester House, Old Broad-street, on Tuesday, the 23rd inst., at 12 o'clock.

THE UNITED ELECTRIC LIGHT AND POWER COMPANY (AMERICA).—The stockholders of this Company have filed a consent to the execution of a mortgage on the property of the Company not exceeding $5,000,000.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated receipts of this Company for the half-month ended September 15th, amounted to £2,384, compared with £2,038 in the corresponding period last year, an increase of £346.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 12, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,698.

WINFIELD'S (LIMITED).—The annual general meeting of Winfield's (Limited) was held on Thursday afternoon last at the Company's Works in Cambridge-street, Birmingham, presided over by Mr. Wilson, Vice-Chairman of the Company, who, in moving the adoption of the report, said: Although the profit which had resulted on the last year's working was not great, they believed they were thoroughly justified in adopting a hopeful and confident tone. The amount had been fairly and honestly earned, and was an indication that the business had turned the corner. The profit had practically been earned during the last six or seven months. They had cut down dead expenses very extensively, consistent with the efficient conduct of the business, and had not been unmindful of the importance of introducing new and special articles. They were cautiously and safely laying down lines of a new manufacturing policy, which they could not discuss publicly, but which would be most helpful to them in the future. The profit earned (£3,592. 15s. 9d., after writing off £2,027 for depreciation) they proposed to carry to the credit of the concurrent year's trading, and thus strengthen and conserve the resources of the Company. They had thought it prudent to take their largest shareholders into their confidence before they submitted this proposal to the Company, and they unanimously concurred in the suggestion, and the auditors also approved it. The Directors now felt the time had come when they must make an appeal to the shareholders for an additional amount of working capital. They were under considerable obligations to their bankers, and if it could be obtained it would preferable to work upon their own capital than upon borrowed money. The report and balance sheet were then adopted, and the retiring Directors were re-elected, as also were the joint Auditors.

THE NON-CONDUCTOR OF ELECTRICITY.

VULCANISED FIBRE,

PATENTED.

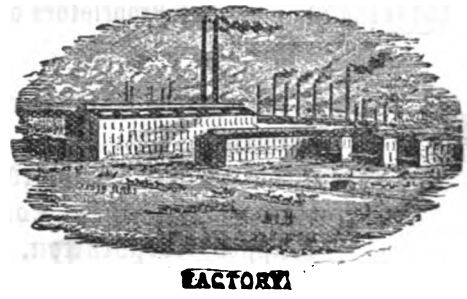
This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 2ft. 6in., varying in thickness from 1-60in. to 1in.



FACTORY.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 10.		Price Wednesday, Sept. 17.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 17.	
£			**TELEGRAPHS.**					£ s. d.		Highest.	Lowest.
1,381,330	Stock	15/0	Anglo-American	51⅛	52⅛	51½	52½	5 4 9	Jan., Apr., July, Oct.	52	51
2,809,310	Stock	30/0	Do. Preferred	87⅛	88⅛	88	89	6 3 7	" "	88⅞	88½
2,809,310	Stock	..	Do. Deferred	15½	15⅝	15½	15⅝	..	..	15⅝	15⅛
250,000	£100	4%	African Direct, 4 per Cent. Debentures	97	100	98	101	3 19 3	January and July	..	..
130,000	10	3/0	Brazilian Submarine	11⅜	12⅛	11⅜	12⅛	5 6 1	Mar., June, Oct., Dec.	12⅛	12
69,200	100	5%	Do. 5 per Cent. Bonds	100	102	100	102	4 18 0	January and July	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	..	..
$7,216,000	$100	..	Commercial Cables	103	105	..	105	..	..	105	..
£16,000	£10	8/0	Cuba Submarine xd	12½	13	12½	12⅝	6 13 1	February and August	..	12½
6,000	10	10%	Do. Preference 10% xd	16⅛	17½	16⅛	17½	5 14 3	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	3¾	4¼	3¾	4¼	5 3 6	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10½	10⅝	10⅛	10⅜	6 10 3	Jan., Apr., July, Oct.	10⅝	10⅛
400,000	10	5/6	Eastern	13⅜	14⅛	14	14⅛	4 11 3	" "	14⅛	13⅞
70,000	10	6%	Do. 6 per Cent. Preference	15	15⅛	15	15⅜	3 17 5	" "	15⅛	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	105	108	104	107	3 14 9	May and November	105	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14	14⅛	14⅛	14⅜	4 17 5	Jan., Apr., July, Oct.	14⅛	14⅛
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	100⅜	..
91,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	103	106	103	106	4 14 4	January and July	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	102	105	4 15 3	" "	102⅜	..
180,227	10	4/3	Globe Telegraph and Trust	8⅜	9	8⅞	9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅜	15	14⅜	15	4 0 0	" "	15	14⅞
150,000	10	5/0	Great Northern	15⅜	16⅛	15⅜	16⅛	4 12 4	Jan., April, and July	15⅞	..
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100	103	100	103	4 17 1	January and July	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	36	38	36	38	6 11 7	April and October	37½	36
38,348	10	4/0	London Platino-Brazilian	6½	7⅛	6½	7⅛	5 6 8	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures xd	105	108	105	108	5 11 1	March & September	..	..
9,000	8	6/0	Reuter's	8	8⅛	8	8⅛	5 19 4	April and October	8⅜	8⅛
3,381	£100 Cert.	..	Submarine Cables Trust	113	117	113	117	5 2 7	" "	117	..
15,609	£10	6/6	West African	9	10	9	10	5 0 0	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures xd	99	102	99	102	4 18 0	March & September	..	..
30,000	10	3/0	West Coast of America	4½	5	4½	5	10 0 0	January and July	4½	..
150,000	100	8%	Do. Debentures 8%	101	106	101	106	7 10 11	June and December	104	103½
88,321	10	Nil.	West India and Panama	3	3½	3½	3⅝	..	..	3⅜	3⅛
34,563	10	6/0	Do. 1st Preference 6%	11⅛	12	11⅛	12	5 0 0	April and October	..	..
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	13⅛	14	13⅛	14	4 5 9	..	..	..
64,572	15	6/0	Western and Brazilian	11	11½	11	11⅛	5 5 3	May and November	11⅛	11
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅜	7	6⅜	7	..	..	7	6⅞
26,986	7½	4/6	Do. 5 per Cent. Deferred	4½	5	4½	5	..	..	4⅞	..
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103	106	103	106	5 13 2	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101	104	101	104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	120	125	122	127	5 10 3	May and November	..	..
£175,100	£100	6%	Do. 6 per Cent. Sterling Bonds xd	97	99	97	99	6 1 3	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5¾	Consolidated Telephone Const. and Maintenance	⅛	⅛	⅛	⅛	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	⅜	⅜	⅜	⅜	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅛	4⅜	4⅛	4⅜	6 3 1	June and December	4⅛	4⅜
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12	12½	12	12½	4 16 0	June and December	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10	10⅜	10	10⅜	5 14 3	" "	10	..
209,750	1	½%	South of England, Ordinary	⅛	⅜	⅛	⅜	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd)	2½	3	2½	3	..	..	..	..
55,000	5	1/0	United River Plate	3½	4	3½	4	..	January and July	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅛	2⅜	2⅝	2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4	4⅛	4	4⅛	..	..	..	..
42,853	5	..	Westminster Electric Supply	1¼	1⅜	1	1⅛	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1⅝	2	1⅝	2	..	..	..	..
63,416	2	1/2	Do. Preference	1⅛	2	xd 1⅛	1⅞	..	..	..	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5½	5⅝	5½	5⅝	..	..	..	..
353,478	5	..	Edison and Swan United	..		..		..	..	..	..
409,000	10	..	Electric Construction	7⅞	8⅛	7⅞	8⅛	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing	7⅜	8⅛	6⅞	7⅛	..	..	8⅛	6⅞
20,000	5	..	Fowler-Waring Cables	2	2⅛	3	3⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18	19	18½	19½	5 2 7	February & August	19⅛	19
200,000	100	4⅛%	Do. 4½ per Cent. Debentures, 1896	102	104	102	104	4 6 7	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5	5½	5½	5⅝	3 12 11	..	5½	5⅝
37,350	12	12/0	Telegraph Construction and Maintenance	42	44	42	44	5 9 3	March and July	43½	43
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100	102	100	102	4 18 0	..	..	..

JABLOCHKOFF'S

DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

THE ELECTRICAL ENGINEERING CORPORATION, LIMITED

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

The list of electric lighting notices for 1890-91, which will be found in another column, shows that considerable activity still exists in this direction. The 474 notices of last year resulted in the granting of 31 Provisional Orders; and if the same proportion should continue to hold good, the 263 notices of this summer may be expected to yield about 17 Orders next August. As there are some 50 Companies concerned in the issue of these notices, they may reasonably anticipate obtaining one Provisional Order between three of them. The vast majority of the notices are, of course, mere *ballons d'essai*, but they no doubt serve a useful purpose, inasmuch as they keep electric lighting before the Local Authorities and oblige them to come to a definite decision with regard to it. Although most of the Companies now in the field were also prominent last summer, there are several new comers, such as Latimer Clark, Muirhead, and Co., and the Sheffield Telephone Exchange and Electric Light Company. The House-to-House Company still continues its shower of notices. Last year 20 and this year 14 have been served by this Company, its metropolitan notices having been mostly repeated. It is to be hoped that this persistence may ultimately lead to some tangible result.

The paragraph in *The Times* announcing that "a new form of electrical generator and motor has been invented by Mr. J. Vaughan-Sherrin, by means of which the propulsion of boats, tricycles, and Bath-chairs is effected without accumulators," has attracted the attention of several of our contemporaries; but the *Spectator* thinks that "it will be necessary to obtain legislation before the new vehicles can legally come into use on the roads, unless, indeed, they are content to move at a foot's pace, and to be preceded by a man with a red flag." This erroneous idea was prevalent among the Metropolitan Police when Mr. Radcliffe Ward began to make experimental runs with his omnibus; but he had provided himself with a licence under a recent, but little known, Act, which was not in operation when Profs. Ayrton and Perry experimented with an electrical tricycle in the streets of London. In the absence of further information, we can only say that, considering the obstacles which are only now being overcome in tramway work, the difficulties of a practical electrical carriage on a small scale are enormous. As it is unlikely that any great improvement has been made in reducing the weight of the motor and its gearing, the invention probably relies on some *new* battery.

The Paper by Mr. Glazebrook on the "Recent Determinations of the Absolute Resistance of Mercury" deals with a subject of wider interest than is suggested by its title. The value of the absolute resistance of mercury does not concern the average electrical engineer any more than the absolute resistance of sodium; but a glance at the contents shows that it treats of a subject with which every electrician should be more or less acquainted. It is a sketch of the recent determinations of the ohm, and being written by one who has not only been engaged in carrying out such determinations, but who has spent so much time in comparing the standards, and in minutely watching and recording any relative changes that appear in their values, it carries the greatest weight. It is, however, a pity that it is so brief, and apparently addressed only to the members of the B.A.U. Committee and others who are concerned in this important work. The value of Mr. Glazebrook's Paper would have been much enhanced to most practical men by footnotes referring to the publications or works in which further information may be found. Few engineers have time to keep up with the work that is done by such men as Kohlrausch and Lorenz, but many of them will follow with interest the results which are obtained. In this country writers do not seem to consider that the bibliography of a subject concerns their readers as much as it concerns themselves; but a German author will generally give a list, and often a very long one, of the authorities whom he has consulted. The Cantor lectures by Prof. S. P. Thompson, on "The Electro-magnet," are an example of the use not only of copious references, but of the manner in which such references should be made.

It appears that the true value of the ohm which has been approached, asymptotically as it were, during the past ten years, can differ but very little from the "weighted" mean of the numerous determinations. The result given in Prof. J. Viriamu Jones' Paper, which is modestly called "Suggestions towards a Determination of the Ohm," 106·307 centimetres, with a probable error of ± 0·012, is nearer the mean of the ten values alluded to by M. Glazebrook than are most of the values themselves; and any new figure which may be hereafter put forward, which differs by 0·05 from that mean, will carry little, if any, weight. The time is, therefore, at hand when a complete account should be prepared of all the methods which have been adopted, with a thorough discussion of the comparative merits of the observations; an account, in fact, of which Mr. Glazebrook's Paper might be an abstract, and of which Prof. J. V. Jones' Paper might be one chapter.

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According to M. Boucherot, in a recent number of *L'Electricien*, the insulation resistance of electric circuits may be obtained in a very simple manner from three observations made with a suitable voltmeter. The volts between the earth and the positive and negative leads are successively measured and added together: the ratio of the sum thus found, to the excess of the voltage of the line above that quantity, can be shown by calculation to equal the ratio of the resistance of the voltmeter to the insulation resistance required. The same formula can be applied to a three-wire system, if by the voltage of the line is understood the total potential between the positive and negative leads. The method seems well adapted to systems of distribution in which low pressure and constant potential are used, and its simplicity and quickness are great points in its favour. Its application, however, must be very limited, as the measurement cannot be at all sensitive unless the resistance of the voltmeter approximates in value to the insulation resistance under test.

A new measuring instrument, bearing the distasteful name of Mho-heure-metre, has recently been made in Paris by M. Frager. The power expended per second in a circuit of resistance, R, and absorbing V volts, is V^2/R, and the time integral of this measures the energy. If V is constant the energy depends on the time integral of $1/R$; and it is this latter quantity which M. Frager's instrument measures. It is difficult to see the purpose served by the new instrument; although its construction, which has not yet been explained, may possibly show merit. If the volts supplied are constant, the energy absorbed may be obtained from the indications, but any ordinary coulomb meter would do as well; while if the volts vary, although neither instrument measures the energy supplied, the coulomb-meter indicates something which is well understood, while the new instrument only gives a quantity unknown, to most electricians.

The occasions on which a practical electrician need trouble himself about the value of H, the horizontal component of the earth's magnetic force, are fortunately very few. Measuring instruments are generally placed in an artificial field produced by strong permanent magnets, and their sensibility determined by the effect produced by the passage of a known current. Moreover, as sensitive apparatus is usually constructed, a knowledge of H would be of but little assistance in deducing the constants, since the complex winding of the coils renders calculation impossible. The usual method of measuring H, that of Gauss, is also so long and tedious, and the apparatus required for good results so expensive, that the determination is avoided whenever possible. If, however, a simple and short method for measuring this quantity could be found out, it is not unlikely that useful applications would result; and it is therefore interesting to find that Prof. Stroud, of the Yorkshire College, Leeds, has been able to devise a method which possesses many advantages over the well-known one of Gauss.

Prof. Stroud's apparatus, which is described in the June number of the *Proceedings* of the Royal Society, consists of a piece of fine pianoforte wire, bent into the form of a circle, the two ends being soldered together. This ring is magnetised like a Gramme armature, with opposite poles at the ends of a diameter, and suspended bifilarly in a vertical plane, with the line of poles horizontal. At the centre of the circle is suspended a small magnetised needle, whose deflection is observed when the plane of the circle is placed at right angles to the magnetic meridian by twisting the bifilar arrangement. The formula obtained for H involves the ratio of two observed angles, the weight and radius of the wire circle, and the dimensions of the bifilar suspension. It does not depend in any way on the distribution of magnetism in the wire; nor is it necessary for the suspended needle to be exactly at the centre of the circle. The corrections necessary are of a much simpler and more certain kind than those required in Gauss's method; while there is no need to go through the tedious operation of determining a time of vibration. The instrument can be made at very small cost; and when the dimensions and other constants of the instrument have been once determined, the time occupied in finding H is only a few minutes. How accurate the method can be made is as yet somewhat doubtful. The correction for torsion of the suspending fibres is rather serious; and the dimensions have all to be measured very carefully, a very difficult matter when some of the lengths are as small as those of a bifilar suspension. The method is, however, one of great promise, and the measurements given show that the instrument, when skilfully used, may be relied on to give results true to one-tenth per cent.

Bromley.—The Local Board have instructed their clerk to take the steps necessary to obtain an electric lighting order.

The Telephone at Manilla.—The Telephone Company at the Port of Manilla has decided to open a floating telephone station in the harbour.

Fire.—We are desired by Messrs. Cathcart and Peto to state that the recent fire at their Hatton-garden Works will in no way interfere with their business.

Appointment.—Mr. E. A. O'Keeffe has been appointed Senior Demonstrator and Lecturer at the City and Guilds of London Technical College, Finsbury, in the place of Mr. W. Robinson.

Personal.—We are informed that Mr. W. B. Sayers has been appointed manager to Messrs. Mavor and Coulson, of Glasgow, who have a number of important installations on hand.

The Westinghouse Strike.—The strike of the Westinghouse Electric Company's *employés* for shorter hours with ten hours' pay and other concessions, has ended in a practical victory for the Company.

Heriot-Watt College, Edinburgh.—The 1890-91 session of this College commences on Wednesday, October 1st. The College is completely equipped for providing higher technical and commercial education.

Editorial Change.—We learn that Herr Arthur Wilke will cease to edit the *Electrotechnischer Anzeiger* from October 1st, and will devote himself exclusively to conducting the new weekly electrical journal, the *Elektricitäts-Zeitung*.

The Electric Lighting of the Paris Boulevards.—On Thursday evening, last week, the electric light on the Boulevard des Capucines was temporarily extinguished, owing to a "burn-out" in a section of the Popp Company's underground system.

Newcastle.—The Newcastle and District Company now supply something like 6,000 ten-candle lights, and hope to supply before the winter is over illumination to the extent of 10,000 lamps. The Newcastle-on-Tyne Electric Supply Company is also busy.

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The Production of Oxygen.—In a recent number of the *Bulletin de la Société Industrielle de Mulhouse*, M. Scheurer-Kestner estimates that about 36 franc's worth of coal is used in producing a kilogramme (700 litres) of oxygen by the electrolysis of water.

Electric Lighting in Gibraltar and Malta.—Mr. Preece left the Thames yesterday morning in the P. & O. ss. "Mirzapore," to visit Gibraltar and Malta, with the object of reporting to the Government on the best mode of introducing the electric light into these fortresses.

Royal Victoria Hall.—The autumn series of science lectures at the above hall begins with two "People's Lectures" (under the auspices of the London Society for the Extension of University Teaching), by J. D. McClure, Esq., on "Nebulæ" (September 30th), and "The Sun" (October 7th).

Electro-Harmonic Society.—The concerts of this Society will recommence on October 3rd, and will be continued on November 7 and December 8, 1890, and January 30, February 27, and April 10, 1891. They will, as before, be held in the Banquet Room, St. James's Hall Restaurant.

Holborn Board of Works.—At the last meeting of this Board, the Committee of Works recommended that the electric light should be supplied to the whole of the public rooms and offices in the Town Hall, &c. The Clerk was directed to communicate with the Metropolitan Electric Supply Company as to terms.

The Telephone at Birmingham.—Telephone transmitters are to be set up in Christ Church, New-street, Birmingham, so that subscribers to the telephone, if they desire, can hear the service and the sermon at their private residences. The transmitters will be arranged at the end of the choir stalls, on the top of the lectern and the reading desk of the pulpit.

City and Guilds of London Institute.—Prof. Ayrton's special course of lectures for outside students will be given every Monday and Wednesday at 3 p.m., commencing Monday, October 6th, and the subject will be "The Construction of Direct and Alternate-Current Dynamos and Motors, and the Methods of Testing their Power and Efficiency."

The Association of Edison Illuminating Companies.—The following are some of the subjects discussed at the Minneapolis meeting of this Association: Lightning Protection—results of experiments; Insurance of Edison Central Stations; a National Code of Insurance Rules; Edison Patent Litigation; Central Station Steam Piping; Re-organisation of Edison Interests; Grounding the Neutral Wire in Three Wire Systems.

Leeds.—At a meeting of the Sub-Highways (Tramways) Committee of the Corporation, held last week, Mr. C. H. Wilkinson, agent for the Thomson-Houston International Company, attended and laid before them a scheme for working the Roundhay section of the Leeds Tramways. It was proposed to equip the section for two years, and at the end of that time to make any re-arrangement that might seem to be desirable, the equipment to be the same as that put down at Boston.

Interurban Telephonic Communication in France.—As soon as a Bill now awaiting the sanction of the Senate has become law, interurban telephonic communication will assume large proportions in France. Bordeaux, Dieppe, Elbeuf, Limoges, Saint-Quentin, Tours, Troyes, Fontainebleau, and several other towns will be telephonically connected with Paris; Grenoble and Saint-Etienne with Lyons; Nice with Marseilles; Montpellier with Cette; Béziers with Narbonne, &c.

Telegraphs in India.—According to an extract contained in the current issue of *The Board of Trade Journal*, the length of telegraph line and cable in British India is 33,462 miles, of which 1,568 miles represent the extensions of the year 1888-89. The number of messages during that period was 2,978,998, or an increase of 176,669 over the previous year. The receipts were Rs632,247, yielding a surplus of Rs198,024 on the revenue account, equal to 4·45, as against 5·46, per cent. in the preceding year, on the capital outlay. The additions to the capital expenditure during the year amounted to Rs174,362, or Rs60,593 less than in the previous year.

Electric Heating.—One of the latest applications of electricity is the heating of pressing irons, which has been introduced in a clothing factory at Minneapolis. The method of conducting the electricity into the pressing iron is as follows:—A spring rod stands upon each table, and to it the electrical wires are connected, running thence into the pressing iron. The current is made to pass through a wire resistance, which is so arranged within the pressing iron as not to come in contact with any portion of the shell of the iron. The wire is raised to incandescence by the current, and the heat thus generated warms the pressing iron to the required degree.

The Telegraph Department at Chin-Lushai.—In the military despatches on the Chin-Lushai operations, mention was made of the excellent work done by the Telegraph Department; but, says the *Indian Engineer*, the civil officers engaged deserve yet further notice, for their labours were of the most trying kind. Field lines of a length of 420 miles were laid, the principal section being from Demagiri to the Upper Koladyne, 104 miles, and from Pouk to the Boinu river, six miles west of Haka, 192 miles. Mr. E. O. Walker laid the former section; and the difficulties he had to overcome were very great, the line running through a dense forest and across a succession of hills from 2,000 to 5,000 feet in height.

Electric Tanning.—M. Müntz, Professor at the Institut Agronomique, has recently published a highly favourable report on the Worms and Balé process of tanning by electricity. All the hides so tanned had, says M. Müntz, the appearance of hides tanned by the ordinary process. Tests with acetic acid showed that the hides were thoroughly well tanned after a maximum of four days in the vats. Further chemical tests showed that the tannin was as well combined with the leather as in the ordinary method. We may mention in this connection, that a large firm of tanners in Paris are sending out, with every consignment of hides, a certain proportion of electrically tanned ones, intimating that any of the electrically tanned skins which are not found up to the mark will be immediately exchanged for some tanned by the ordinary process. No electrically tanned skins have as yet been returned.

Telephone Contracts.—The following letter from Mr. A. Erskine Muirhead appeared in the Glasgow *Evening Citizen* of Saturday last:—

"I have been a subscriber to the Telephone Exchange for some years; but recently having introduced to the notice of the telephone company and the city generally some French telephones, and at the request of a number of firms agreed to run wires and fix those telephones when the patent expires, it was quite to be expected the telephone company would be annoyed, seeing the rate proposed by me to erect wires and sell the telephones outright was not more than the annual rental charged by the National Telephone Company. They at very short notice cut off my telephonic communication with their system, though I had signed a contract in which six months' notice was required by either side. As they keep these contracts, when I applied for redress they denied my ever having signed such a contract, though their rules, as printed in their own directory, say, 'Each subscriber must sign a contract specifying the terms and conditions under which the service is supplied.' I am the sole exception, out of their 2,000 Glasgow subscribers, who has not signed a contract."

Electric Tram Accident at Florence.—A fatal accident occurred on Wednesday on the electric tramway between Florence and Fiesole. The cars ran off the track, five persons being killed on the spot and twenty others injured. In connection with this accident Mr. E. Manville writes:—"The reports published on the above regrettable accident are liable to produce an impression that the fact of the tramway being propelled by electricity was the cause of the accident. But from details already received it is clear the accident was due only to an inexperienced driver omitting to shut off the current from the motor when going down hill, and exactly the same results would have followed had the car been propelled by a steam locomotive, or indeed any form of mechanical traction involving the use of independent motors."

An American Invention.—John Bull, says our esteemed contemporary, the *Electrical Review* of New York, is green with envy over the rapid strides taken by American inventors in the field of invention. The English journals at every issue contain some slur intended to detract from the value of the great inventions in power, lighting, telegraphy, or the multiplicity of applications found for the subtle fluid by the ingenious American. It is, doubtless, very hard for our English cousins to admit that

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they are beaten in the contest of brains, but they can scarcely fail to realise the situation, and it would be more creditable to bow gracefully to the inevitable. Just now they are directing their slings at the phonograph, and assailing its commercial usefulness. It has not taken the public on this side of the pond long to learn how to employ this marvellous instrument. The thousands of instruments in active use by business men in the despatch of their daily routine is a safer criterion of the commercial value of the invention than the slurs of quasi-scientific scribblers, who, if they laboured until the crack of doom, could give birth to nothing more useful than a few tomes of platitudinous twaddle.

An Edison Electric Generator.—One of the latest and most curious outcomes of Mr. Edison's inventive genius is an apparatus for generating electricity by causing the magnetic circuits of a series of electromagnets to be alternately made and broken. To effect these interruptions of the magnetic circuits Mr. Edison employs the agency of heat. The electromagnets, which are magnetised nearly to saturation, are attached to the ends of a number of arms consisting of sheets of nickel secured to end pieces. These arms, mounted in openings in the top plate of a short cylindrical furnace, project radially from its centre, the top plate extending beyond the sides of the furnace so as to keep the magnets cool. Inside the furnace is a slowly revolving shield, covering one half of the openings in the top plate. One half of the nickel arms are thus cooling while the others are being heated; in other words, one half of the arms will be contracting and the other half will be expanding. Now, as the magnetic circuits are pivoted at their centres, these expansions and contractions cause the circuits to be alternately closed and interrupted. At the points where the magnetic circuits are broken, coils are wound in which currents are induced by the alterations in the value and distribution of the magnetic flux. *Parturiunt montes, nascetur ridiculus mus.*

The Disengagement of Heat and Light in Electrical Discharges.—In a recent number of the *Beiblätter der Physik*, G. Staub describes how he determined the ratio of the total energy (E) emitted by a gas to that which is perceived as light (L). He introduced a Geissler tube into an ice-calorimeter, from the bottom of which the mercury was removed. The ice and water transmitted all the rays of light, and only absorbed those of heat. He then blackened the Geissler tube, and thus retained the visible rays also in the ice-calorimeter. If the quantity of heat in the first case is Q and in the second E, $L = E - Q$. The width of the Geissler tube was altered as well as the pressure in it, and condensers and also breaks were interposed in the circuit. The results of the experiments were as follows. With the help of electrical discharges in Geissler tubes, light of considerably greater useful effect may be obtained than in the glow-lamp. The maximum for one of Blattner's was 10 per cent., and for a Geissler tube with condensers 32·8 per cent. The useful effect increases with the density and quantity of electricity which passes through the tube. It decreases as the pressure and diameter of the capillary tube increases. If the Geissler tube is filled with hydrogen, the optical effect is less than in air, other things being equal. These results agree with the experiments on glow-lamps and flames, in so far that the higher the temperature the higher in general is the useful effect.

Municipal Telegraphy and Strikes.—The dependence of the police in large cities for the efficiency of their system upon the telegraph is, says the *Western Electrician*, illustrated in the following story concerning the big strike on the New York Central Railroad. When the strike of the New York Central road was declared, some four weeks ago, the police wires on the east side above Fourteenth-street did not respond. The operator rushed into the inspector's office in great excitement with the news. The wires were tried again without response. Four linemen were sent out to find and repair the break; and orders were sent over the Western Union wires to forty detectives to report at once to police head-quarters. These men were stationed where they could get telephones, and were instructed to keep the central office informed of the actions of the strikers. At 8 o'clock the linemen reported that they were unable to locate the break in the police wire. In the meantime it was telephoned from the Murray Hill Hotel that the signal station switches at Fifty-seventh-street were threatened. The inspector sent out the linemen again, and an hour later they came back unsuccessful. The circuit was ultimately completed by using a Western Union wire from Fourteenth to Thirty-fifth streets, and the anxiety of the police inspector was relieved.

The Storage Battery in the Chicago Telephone Exchange.—For some months, says the *Western Electrician*, the Chicago Telephone Company has been ringing its subscribers' signal bells by means of current from the Chicago Edison Company's system. The apparatus consists of a small commutator driven at about 700 revolutions by a water motor. By this arrangement alternating current necessary for the operation of the bells is obtained directly from the Edison wires. The Company is now introducing a system through which the primary batteries working on all local circuits will be replaced by storage batteries charged from the Edison house circuit. Each group of storage cells is divided into two sets of five each. The cells of each set are charged in series, the charging current coming to them through a lamp resistance. By means of switches, either of the two sets of a group may be cut into or out of the lamp circuit and thrown into service on the local wires. By the use of the storage batteries, it is said, the local service is much improved. Much valuable space is saved by the difference in the room taken up by gravity cells and accumulators In addition to the above adaptation, Mr. O'Connell, the Electrician to the Company, also proposes to employ storage cells in connection with subscribers' telephones. His plan is to remove the primary battery and instal a small accumulator at any telephone where the Edison lighting wires may be tapped. Connections are to be made in such a manner that when the telephone is in use the released hook-lever will throw the Edison current into the storage cell through a lamp resistance. The accumulator will ordinarily be connected in the same manner as the primary battery was, and the Edison current will only be flowing while the subscriber is talking. Hanging the telephone on the hook breaks the circuit to the Edison mains.

Electric Transmission of Power for Railway Tunnelling Purposes.—*Engineering* of September 19th contains an interesting description of the works in connection with the construction of the Santa Rosa—Mendoza section of the Buenos Ayres with Valparaiso railway line. This section of the line crosses the Andes by a series of tunnels, the highest of which is at an altitude of 10,466 feet above the level of the sea. The greater portion of the tunnelling is through very hard rock, and it was found necessary to employ drilling machinery to expedite the work. As the cost of fuel would have been great and there was not sufficient water power close to the entrances to the tunnel, it was decided to utilise the water found in the valley below, and to transmit the power by electricity to the tunnel faces on the mountain sides above. Two installations have been made, one on the Argentine and the other on the Chilian side of the Andes. On the Chilian side a head of water of 600 feet and on the Argentine side a head of 400 feet can be obtained. The water thus obtained at considerable pressure is used for driving Girard turbines. On the Chilian side there will be twelve 80 horse power turbines, working at 700 revolutions per minute, each turbine driving direct on to a 54 kilowatt (400 volts × 135 amperes) dynamo. From this installation the power is conveyed to Juncalillo, about two miles distant, from six of the dynamos to six 60 horse-power motors, whilst the power of four dynamos is carried to four 60 horse-power motors at Calavera. In each case the motors make 600 revolutions per minute and drive air compressors, capable of compressing air to six atmospheres. The power from the Argentine side will be carried about two miles to Las Cuevas. The cables, made by Siemens Bros. and Co., are covered with a special insulating preparation and encased in lead and further protected by an outer covering of plaited jute. Four installations of electric light have been provided, each absorbing 10 horse-power. Telephonic communication will be established between the two generating stations. As this is probably the first instance in which electrical transmission has been used for tunnelling purposes on so large a scale, it will be interesting to watch the results.

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THE BRITISH ASSOCIATION MEETING AT LEEDS.

BY DR. OLIVER LODGE, F.R.S.

Once more has Section A been overladen with the weight of its own material, and full discussion has been of necessity choked. There is nothing of a grievance in this statement; it is the result of the great activity in all departments of Physics at the present time, and it is easier to point to the evil than to find a remedy. Already it is necessary to practically divorce Mathematics from the rest of the subjects, and take it by itself at a time when the main body of the Section is sitting elsewhere; and this is by no means a satisfactory or desirable occurrence. The Pure Mathematicians attend during many physical communications; and it is only reasonable that Physicists should keep in some sort of connection with the progress of Pure Mathematics. In old days the overlapping of the two sets of minds on the mathematical field-day sometimes produced brilliant results.

With the chair occupied as it was this year by an eminent Mathematician, who, though a specialist in one sense, is known to be interested in a wide range of subjects outside his special domain, it was to be hoped that some memories of the meeting at Bradford would be revived; but the press of business ordered it otherwise, and a great part of the members were called away on electro-chemical duty during the mathematical session.

Yet some bifurcation seems absolutely essential, and an opportune proposal is understood to come from the Meteorologists suggesting a sub-section for their department. By splitting off Astronomy, and Spectroscopy, Terrestrial Magnetism, Meteorology, and Photography, into a sub section, meeting regularly on several days but arranging so as to read their Papers of most general interest on, say, Monday, when the main Section might either abstain from sitting or take its more formal reports, considerable relief might be afforded, and a fairly mathematical Saturday might again be possible. The other proposal is to divide into General Physics on the one hand and Electricity on the other. It is characteristic of this particular portion of the century that such a proposal can be seriously contemplated, but it seems to me highly undesirable thus officially to widen a breach which the populace is already too willing to detect and emphasise. Moreover, an electrical sub-section would soon become an omnium gatherum of some of the highest flights of scientific speculation on the one hand, and some of the trivialest forms of "cut-out" on the other. A mass of patent devices and practical detail, highly useful in their own way but scientifically considered of little significance, would tend to accumulate in such a sub-section, whereas their more appropriate place is Section G.

Whatever has for its main interest the practically useful and commercially advantageous seem to me to belong by rights to the Engineering and Applied Science Section; and some slight relief would sometimes be afforded to Section A if this proposition were admitted and acted upon.

I admit at once that the scientific engineer might, if he chose, entirely repudiate any such contention, and taking his stand on the undoubted fact that pure mechanical engineering is a science irrespective of any possible uses in the arts, might repel the insinuation that he was mainly concerned with practical utility, and assert that he dealt with abstract mechanical science. But from what one knows of the past associations of the section, such an objection is not likely to be really made; and Applied Electricity is already assimilated by it just as much as applied Heat and Mechanics.

And a highly interesting department of knowledge is thus constituted. Applied and pure science are to be separated not because one is less exciting than the other, but because the attitude of mind appropriate to one is inappropriate to the other, and wherever you try to combine or alternate them they clash.

As to general interest, there can be no doubt, indeed, that the applications of science, the developments wherein abstract science begins to touch the needs or increase the power of humanity, have by far the greatest interest for the bulk of mankind. And if the disciple of pure science feels a little sorry when a great opportunity, like a Presidential Address for instance, is thrown away in pointing to and eulogising those conspicuous facts which every newspaper teems with and every commercial traveller knows, it is not because he does not appreciate Atlantic cables and Forth bridges, electric traction, arc lamps, telephones, the United States, Wheatstone's bridge, petroleum oil, and natural gas; but because these things are already so dinned into the public ear by their own well-beloved organs that to prelude what is assumed to be a great scientific gathering by a further reverberation of the big drum seems scarcely dignified or suitable; seems, indeed, calculated to mislead the public as to what real science is, and to excite in the minds of its devotees a grating sensation, somewhat as though a "sky-sign" advertisement had intruded itself on the foreground of a cathedral view.

One of the most prominent subjects of discussion during the present meeting in Section A has been the most probable approximation to the C.-G.-S. unit of resistance; in other words, the most probable value of the old British Association unit in terms of the true ohm. Mr. Glazebrook had tabulated the measurements of different workers during the last few years with scrupulous care, and discussed the different methods which had been employed, with the object of deciding on the amount of accuracy to be hoped for from each. After long consideration of the figures so tabulated, and hearing from Mr. Glazebrook a full statement of the conclusions to which he felt himself led, the Electrical Standards Committee ultimately, on his advice, adopted the number ·98656 as the closest present practicable approximation to the ratio of the old British Association unit to the ohm; and they accordingly instructed him to employ this factor in issuing or certifying true ohm standards based upon the old units. The last figure in the above number is, however, quite uncertain, and the penultimate figure may be wrong by one unit. Such an error, which is only one part in ten thousand, is of no moment whatever for practical purposes, and is getting rather near to the limit at which accuracy in absolute physical measurements is possible.

Indeed, without the most scrupulous care it is not easy to know precisely what the value of the British Association unit itself is. At Cambridge there are a number of copies of the standard, and in a few physical laboratories old and authentic copies are preserved. At intervals of a few years those in England are collected together and rigorously compared with each other by means of Carey Foster's method and Fleming's bridge, great pains being taken to ascertain the temperature of each coil and also to determine its temperature coefficient. Some of these coils retain a satisfactory constancy among themselves, others exhibit a kind of secular change, notably one very important coil F (important because used largely by Lord Rayleigh), which has diverged from the general average by as much as seven parts in ten thousand, so that to make it agree with the others it has to be altered in temperature nearly half a degree. The process of comparing coils with each other is one of such comparative ease and extreme accuracy that a divergence of this amount is very conspicuous. Although the change may be described as secular it is not necessarily to be supposed gradual; it may have occurred at definite epochs while some operation was being performed upon it; while, for instance, it was immersed in an ice bath.

Not the general mean of all the coils, therefore, but the mean of those which keep practically unaltered among themselves, is taken as the value of the old B.A. unit; and on the basis of this and the factor given above, something very near a true ohm can be now issued or certified at the Cavendish Laboratory.

But outside Cambridge matters are different. On the Continent, for instance, or in America, no one knows with any precise accuracy what the British Association unit is. Copies can, of course, be purchased from instrument makers, but there is no guarantee that these shall exactly agree with the mean of those under test at Cambridge; and the discrepancy between different copies made at different times may easily be as great as the uncertainty nowadays attaching to an absolute determination. It is customary, therefore, to appeal to a totally different kind of standard, one that may be set up in any locality and at any future time, and to state the net result of all the determinations in terms of this. This is the object of

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the mercury standard; it is not an easy or convenient standard to replace a wire coil, but it is a standard which, having been once thoroughly determined in terms of the British Association unit, may henceforward at any time with due care be constructed, and the old values redetermined by means of it, even though all present standards were destroyed by fire. Applying the above given factor to all the exact determinations of the specific resistance of mercury, arithmetic gives the number 106·3 as the length of a column of mercury at 0°C., 1 square millimetre in cross-section, which most nearly has the resistance of a true ohm. The range of probable inaccuracy lies between 106·25 and 106·33, the range of possible error being scarcely any wider than this; and the value most in accord with Mr. Glazebrook's instinct being 106·29. Independent and highly elaborate determinations, made in America, France, and Germany, all lie practically within these limits; and there can be little harm done if Government should see fit to make use of the labours of the Committee at this stage, or soon after the Paris Congress has sat next year, and confer authority on 106·3 as a legal and world-wide standard. No further addition to our knowledge can then be commercially significant. If only 106·25 had had the good fortune to be adopted four years ago at the previous Paris Congress, as urged strongly by the British delegates, on the strength of the measurements of Lord Rayleigh, and as supported by both France and America, all this trouble and indecision would have been spared. Failing to carry the ·25, through the opposition of certain representatives, who, by adding up a number of determinations and taking an unweighted mean, arrived at the number 106, it would have been happier if the Congress had declined to come to any decision in the matter; for a legal ohm which was never legal, and was always incorrect, has been an incubus and common nuisance for four years. Fortunate we are to get rid of it before its allotted period of 10 years has expired.

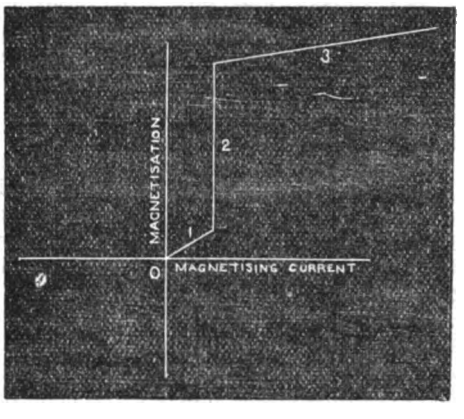
Prof. Viriamu Jones, of Cardiff, was able to bring the results of his own recent and very careful determination of the absolute specific resistance of mercury at 15½°C. by the most direct possible method (a combination of Lorenz's method with Carey Foster's), employing exact engineering appliances and workmanship. Of course it agrees with the others within the usual limits (it is, in fact, 106·307 when reduced to 0°C.), and he feels enthusiastically sanguine that now is the time to undertake a final and abnormally accurate determination, aiming at a sixth significant figure.

The British Association has almost from the beginning taken such a leading part in the introduction of absolute measurement into electrical science, its long-established committee on Electrical Standards being one of the weightiest and best known of its committees, and having a great influence all over the world, that a couple of mornings was none too much to give to a thorough explanation of these matters in the Section; and the meeting will be remembered as one largely occupied with questions of refined accuracy. A general and lighter discussion on electrical units in general, which had been announced and prepared for, had from this cause to be postponed, first to Wednesday, and thence by press of work *sine die*; but a future time can doubtless be found for it, either at Cardiff or at Edinburgh, and, meanwhile, opinion can be matured and suggestions made by circular or correspondence. Doubtless it would have been some relief to the Section to have a light skirmish by way of diversifying the proceedings of the heavy-armed troops; but it is better to finish a thing thoroughly when begun, and the Leeds meeting of Section A has been characterised by good solid work, very little time being afforded for frolic or diversion.

The most brilliant Paper communicated to the meeting, and the one likely to be most fruitful of consequences (so it seems to the writer), was the one on the "Induction of Magnetism," by Prof. Ewing. Ever since the time of Ampère, physicists have been familiar with the idea that a magnetic substance consists of an assemblage of minute magnets, which by the act of magnetisation are made to face on the average in one direction, instead of continuing to lie higgledy-piggledy, as they did when the substance was not magnetised. And this view of magnetisation, that it consists in facing round already magnetised molecules, rather than in exciting magnetism in previously inert molecules, has been experimentally proved in several ways.

But when it came to entering into detail concerning magnetic induction (the term "induction" being here used in what Sir W. Thomson considers its only proper signification, viz., to express the simple old operation analogous to electrostatic induction, the magnetisation of iron by immersion in a magnetic field), there was room for considerable uncertainty as to the kind of process going on. Everyone knows that when a substance is subjected to magnetising processes, some of the magnetisation excited is only temporary, while some continues permanently after the magnetising forces are withdrawn; a fact which may be expressed by saying that the molecules are strained out of their old positions into new ones, and when released they spring back part way toward their old positions, but do not completely recover unless the strain has been very small, or the iron excessively soft. The whole process is so analogous to what is known of the behaviour of solids in general that it has been natural to think of it as a kind of elasticity, accompanied by a kind of permanent set, as soon as the elastic limits are overstepped. *And so no doubt it is.* The molecules are jammed into their positions by something analogous to solid friction, but with a certain freedom or elastic yielding for small ranges of disturbances.

The behaviour of a set of magnetised molecules had been worked out theoretically by Weber and Maxwell on the elastic solid hypothesis; but the correlative hypothesis that instead of being subject to arbitrary mechanical force they might be perfectly free molecules, subject only to their own mutually perturbing magnetic forces, although suggested, had not been theoretically attacked or developed. Prof. Ewing has attacked it experimentally with brilliant results. Even with so crude a model as an assemblage of pivoted compass needles in a plane he has been able to imitate a great deal of the known behaviour of magnetic substances very satisfactorily.



Plotting the magnetisation developed in bodies against the magnetising force applied, everyone knows the curve obtained—the characteristic curve of a dynamo, in fact. This curve looks very much as if it were the smoothing out of three distinct almost linear portions, which I will call 1, 2, and 3. In portion 1 the susceptibility is small, and we are within the elastic limits, so that if the force be withdrawn everything subsides back to the origin. But at a certain point instability sets in; magnetisation increases with enormous rapidity, and if the force be withdrawn now, the magnetisation returns, not to O, but to a point on the vertical line above O, the height of which point indicates the permanent set. This rapid sort of viscous yield of the material continues until another critical point is reached, the beginning of portion 3, when again elasticity supervenes, and no further permanent magnetisation can be got by increasing the strain, only a slight increase of temporary effect; the iron is said to be nearly saturated.

All this Prof. Ewing finds his flock of compass needles able to imitate. First, when joggled in any irregular manner, they set themselves in some regular pattern having no resultant magnetic action, neutralising each other so far as outside space is concerned. Then, when a current is passed

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round them they deflect a little in such a way that they can swing back to their old position when it stops. Increasing it further, they begin one after another to topple round into some fresh position, wherein they combine to produce a resultant outside magnetic effect, giving the second portion of the curve. Finally, after they have all thus revolved, they can be deflected a little more towards the exact line at right angles to the magnetising current, but only in a temporary or elastic manner, springing back into their newly-acquired stable position when the current is stopped.

It is unnecessary to follow the process of reversal of magnetisation in detail; it can be easily imagined. Suffice it to say that all the known phenomena called hysteresis can be imitated by the model, and many other things too, less obvious on their surface.

This conception of molecules subject only to known mutual forces and subject to no obscure constraints either elastic or viscous, free from solid friction and every other vague force, is a tremendous simplification in the dynamics of magnetism. Neither does it limit itself to magnetism alone, for, as both Osborne Reynolds and Fitzgerald said at the meeting—as Ewing indeed began to hint in his Paper—it gives a hope of explaining similarly all the properties of solids. For, as I have above said, the molecules of a magnetic substance do behave elastically, do yield viscously, and do get set by solid friction into new positions. The model does not deny these propositions, but it takes us underneath the vague statements, and shows us, at least for magnetic substances, what elasticity and viscosity and solid friction really are. It reduces the behaviour of solids to the action of free molecules acting on one another by simple and calculable polar forces. And for non-magnetic substances, as Fitzgerald hinted, and as Maxwell (I think he said) began to work out, there may be crystalline or some other polar forces to take the place of the magnetic force in Ewing's model.

If, as Ewing surmises, when a substance enters the liquid or pasty condition, every molecule begins to spin on its axis, all polarity should at once disappear, and the peculiar properties of a solid body should likewise disappear with it.

It is not to be supposed that all magnetic phenomena are completely explained; many can be thought of which the model does not yet seem to touch; but an immense step has been made towards understanding the structure of a solid; and with the cessation of vagueness, and the emphasising of a definite calculable action among the molecules, much progress in solid dynamics may be expected.

The theory of free molecules possessing velocities of translation (a gas) has long been known. The theory of stationary molecules, subject to simple mutual constraints, already by Boscovich and others begun, may now be developed. The intermediate theory, expressive of the properties of liquids, seems likely to lag a little behind the other two.

Another very interesting communication was an account by Mr. H. G. du Bois, in excellent English, of some researches he had been conducting in Prof. Kundt's laboratory on the passage of light through metals. A very thin film of metal is electrolytically deposited on a glass plate prepared to receive it by an infinitesimal spray or evaporation from an electrified metallic point. By the use of a point-anode held close above the plate, films of graduated thickness are deposited in somewhat lenticular form, but everywhere thin enough to be just transparent. Places with sufficiently flat surfaces are selected on the film, and all the rest is covered up with black varnish. Some of the flat surfaces being on a slope, a prism of excessively small angle is obtained, and the light in passing through this is deflected by a measured amount. The experiments are delicate and difficult, but the results exhibit surprising concordance. Using the term "index of refraction" in its ordinary elementary sense, the result is that copper, silver, and gold have an index less than unity, while iron and most other metals have an index of about the value two or three, differing for different kinds of light in a normal manner.

Prof. Kundt seems to suppose this to mean that light travels through the first three metals at a pace greater than its speed in vacuo; but, as Sir W. Thomson pointed out, no conclusions based on ordinary laws of refraction can be held valid for these extraordinarily thin films, whose thickness is less than the wave length of light. The ordinary theory of refraction, and the idea of an index of refraction, tacitly assume that the thickness of substance is great compared with a wave length; and a special theory for very thin films would have to be worked out. Moreover, the disturbance due to rapid absorption and consequent anomalous dispersion is likely to be so great in opaque substances like metals that no simple theory can be applicable. Sir William indeed doubts the advisability of using the prism method at all in such cases as this. He would prefer films of uniform thickness, the retardation (or acceleration) of light in passing through them being measured by some interference method. In this way results would be obtained which, though far from obviously interpretable, would be as amenable to theory as any that could be got; and the gratuitous complication introduced by the varying thickness of a prism would be avoided.

Experiments on the optical properties of metals, though severely difficult both to carry out and to interpret, are obviously of great moment towards a full understanding of the properties of ether, and the way in which it is modified by the presence of an electric conductor.

Sir William Thomson read two connected Papers on the laws of alternating currents in wire conductors. The first was a continuation and development of the investigation into which he was led by considering the formula for a ballistic galvanometer, and the mode in which the whole of the wire was ultimately effective in conveying its share of current, although at first sight the outside conveyed an abnormal portion. His conclusions were completely in accord with experiment as to the equal conveying power, but unequal dissipating or heating power, of different metals. The analogies which hold between distribution of current in conductors of various shapes subject to rapid alternations, and the distribution of density when the same conductors are statically charged, are interesting, and with perfect conductors, as Rowland has shown, are complete.

The second Paper was an examination into the question whether conductors of too great thickness might be not only *in*effective for the conveyance of alternating currents, but actually *anti*-effective in respect of dissipation of energy and production of unnecessary heat. The question put mathematically whether such anti-effective copper was possible was answered in the affirmative, to the surprise of many present. It seems that just as stray lumps of copper in the neighbourhood of an alternating circuit, by having Foucault currents induced in them, will dissipate energy (notwithstanding that they manifestly decrease the total impedance of the circuit near which they are), so also will masses of copper not stray, but pretending to form part of the effective conducting circuit. Doubtless the effect is more marked when the circuit forms a coil, but it exists even in a simple pair of parallel conductors. Discussion of these important Papers was impossible, owing to the lateness of the hour and the still crowded state of the agenda paper.

Prof. Fitzgerald brought forward a case in which practical stability could be secured with an essentially unstable class of forces by supposing a continuous oscillation of particles under the action of mutual forces and under conditions securing not static, but kinetic stability.

He also subsequently made a further small contribution to the incubating Hydrodynamic theory of the Universe, by pointing out that the tendency which a vortex filament ether has to tie itself into knots could be postponed indefinitely by supposing the filaments were very far apart in proportion to their diameters; this hypothesis being shown not to interfere with its power of transmitting energy. At present the vortex theory of the ether labours under a great many difficulties, for not only does such an ether decline to be perfectly transparent to liget now, but it threatens to gradually change its properties with time, containing within itself the seeds of its own entanglement. Problems like this, however, are not to be solved in a few years; and, though present prospects of the theory look dark, some further discovery may suddenly change the aspect of affairs, and verify what at present can only be regarded as a brilliant speculation.

The present writer discussed the theory of the mechanical forces acting on electric resonators and other conductors con-

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veying transient currents, and tried to estimate the magnitude of the effect looked for by Mr. Boys (*see* September *Phil. Mag.*), and also the magnitude of the thermal effect first observed by Mr. Gregory, using Hertz's theory. The fact that a small electric oscillator radiates to a moderate distance with greater intensity than terrestrial sunlight while it lasts was regarded with some interest; but it is to be remembered that were steady sunshine as intense as is the intermittent artificial radiation, not only would metals exposed to it get heated by Foucault currents in the way they do, but a continuous torrent of sparks would be apt to pass between contiguous pieces of metal, especially when some period of solar vibration happened to agree with their own. The energy of solar radiation, however, is spread over a considerable range of wave length, the greatest portion of it being embodied in extremely short waves somewhat below the red end of the spectrum, whereas the energy of an artificial radiator is embodied in very much larger waves, which are mostly all of the same size; it, has, therefore, a more concentrated spark-producing character.

An account of some experiments by Prof. Trowbridge, in America, on photographing the oscillatory discharge of air-condensers at Harvard, was also read; but the present writer threw doubt on the conclusions deduced from Prof. Trowbridge's observations that the effective capacity of an air condenser depends on the rapidity of its vibrations, *i.e*, that its dielectric coefficient is not a constant; pointing out that the capacity of the leads was able to produce something very like the anomalous results which had been detected by the author of the Paper. On the other hand, if the conclusions of Prof. Trowbridge withstand this criticism and turning out to be valid, it will be a matter of considerable interest and importance.

The communication from Prof. Fitzgerald, entitled, "An episode in the life of J," was an outcome of the well-known discussion begun at Bath, on the propagation of electrostatic potential, and the most appropriate form of Maxwell's equations of the electro-magnetic field. As already known, Maxwell's equations appear to leave the question of the propagation of electrostatic potential vague, as something depending on ethereal volume elasticity, a quantity about which nothing definite is at present known. Maxwell seemed to suppose it infinite; Thomson has recently suggested that it may be zero; while Helmholz seemed to provide opportunity for everything by calling it k, and making the propagation of electrostatic potential explicitly depend upon it.

Fitzgerald and others have argued, however, that electrostatic potential is not propagated *per se* at all, but that it is the consequence and residue of a subsident electro-magnetic field; and hence, if it can be said to be a travelling entity or to have any velocity of propagation, it must be said to travel at the same rate as an electro-magnetic disturbance, viz., with the velocity of light; but that the best mode of regarding the matter is not to attend explicitly to the electrostatic potential (Maxwell's function Ψ) until everything has settled down and become static. That electrostatic ideas, in fact, are not appropriate to the conception of kinetic phenomena. The discussers at Bath were led to perceive that Maxwell's occasionally introduced function J, which is connected with Ψ in a definite manner, was much more convenient, and should be explicitly employed in preference to it. Fitzgerald is now able to point out the reason why Maxwell dropped J at an early stage in considering periodic disturbances, and to put his finger on the mistake, viz., that the linear relation for it $\frac{d^2 J}{dt^2} = 0$ is erroneous, and that the true relation is $\mu K \frac{d^2 J}{dt^2} = \nabla^2 J$, which at once gives a wave propagation travelling with the velocity of light, and eliminates from the subject every question connected with the compressibility of the ether and Helmholtz's constant k. Hertz has virtually independently revived the J function under the name H, and has shown that it is most useful in working out his oscillator results.

Although there was no time for discussion, Sir William Thomson expressed practical agreement with Fitzgerald; and since Mr. Heaviside had already informally expressed himself regarding Helmholtz's theory as "Maxwell's run mad," there can be little doubt but that the matter is settled, and will be henceforth quite straightforward.

Lord Rayleigh described a beautiful method by which he had examined the effect of various amounts of contamination on the surface tension of water. It has long been known that waves of different length travel over the surface of liquids with different velocities, not at all like the waves in the interior of simply-constituted substances, whose every size of wave travels at one pace. Large water waves travel quicker the bigger they are; so that Atlantic rollers speed along at a prodigious pace, quite eclipsing the steamers and competing closely with express trains. The speed varies, in fact, directly as the square root of the wave length. With minute waves or ripples, Sir William Thomson has taught us, it is quite otherwise. Their propagation depends not on gravitation, but on surface-tension, and they travel quicker the smaller they are, so that infinitesimal waves flash across the surface with immense velocity—a velocity inversely as the square root of their lengths. Of course the two classes, waves and ripples, merge into each other, there is no sharp line between them, and there is accordingly a ripple-wave of small size which is the slowest possible. But it was the ripples proper of which Lord Rayleigh wished to make use, in order, by help of their observed velocity, to measure the tension of the surface on which they were formed. The problem then was to produce a regular succession of very minute ripples, and measure accurately their velocity of travel. The method adopted was to cause a point attached to the prong of a tuning fork to throw the surface into crispations at a known frequency, and to measure the wave-length of the ripples so caused. To measure them it was necessary to render them stationary, either actually by reflection, or optically by some intermittent-vision device. The optical method was preferred, vision of the surface being obtained between the pairs of overlapping slits attached to the prongs of another synchronised fork. Thus the ripples might be seen as if stationary, and their number to the inch counted. But before doing this, there is another requirement to be attended to. The theory of waves in its simple form applies only to disturbances of infinitely small amplitude; at least, to amplitudes much smaller than the wave-length. To be at all accurate for these minute ripples, therefore, the permissible amplitude must be too small to be ordinarily visible, and here comes in the most beautiful part of the method. The water surface is illuminated by a convergent beam which, after reflection, comes to a focus at a point above the water. At this focus the eye of the observer is placed, and accordingly sees the water surface, if steady, as a uniform sheet of light. But the slightest shiver or irregularity of reflection, by concentrating the light in some places and removing it from others, becomes exceedingly conspicuous. With all these appliances then working properly, the ripples are seen like fine shading or narrow stripes, looking like the interference bands of optics.

By this series of ingenious contrivances the surface tension could be quickly measured for a variety of surface contaminations, starting with clean water and adding known proportions of oil, of soap, or of other materials.

A clean water surface is obtained by a delightfully simple process. A clean dish is first filled with fresh tap-water, which already is almost absolutely free from grease, and then by an expanding metal hoop (which itself must, of course, be perfectly clean) a small portion of the central surface is stretched to a large area, so that any residue of contamination is thinned out a hundred times and becomes utterly inappreciable. This is not the place to quote results, but it seems that the surface tension of pure water has by several observers been exaggerated. Instead of 80 dynes per centimetre (or ergs per square centimetre), it is only 74. With oil added till camphor particles are just killed, it is 53; with as much olive-oil as it cares to take, 41; and saturated with soap, it is 25.

Prof. Ramsay communicated some initial results of an ingenious method of examining the physical properties of saturated vapours at high pressures, near their critical temperature, which he had devised in consultation with Prof. Fitzgerald. It consists in obtaining Kundt's dust figures in a small-bore tube of an Andrews's press full of the vapour, by

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stroking the tube till it squeaked. The wave length shown by the dust pattern, combined with the pitch of the note, gives the velocity of sound in the vapour, and thus gives the ratio of its adiabatic to its isothermal elasticity, or the ratio of its two specific heats. The fact that a saturated vapour can transmit sound at all is interesting, for one group of them, like chloroform, liquefy on adiabatic compression, while another group of them, like steam and ether, liquefy on adiabatic expansion; hence in the sound wave it is by no means clear what is happening. Absence of nuclei is one mode of avoiding the apparent difficulty. Hurry is another. But so far as I know a complete theoretical investigation into the circumstances has yet to be made.

Sir William Thomson described what he considered, and what doubtless is, the best method of measuring the magnetic susceptibility of feebly magnetic or diamagnetic bodies. There are many objections to Faraday's old qualitative plan of suspending bodies between conical poles, and observing their axial or equatorial set; anything metrical obtained by this method, with say, ellipsoidally shaped bodies, is apt to lead, and in practice has led, observers to ridiculously futile results. The method now laid down consists in taking a magnetic field, varying from one uniform value at one place to another very different uniform value at another. The body to be experimented on is to be cut in some regular slab form, and suspended with one boundary in one of these regions and another boundary in the other. The force with which it is drawn in or pushed out of the strongest region is then to be observed. Afterwards, by measuring the two field intensities, and the dimensions of the piece, the susceptibility of its material can be calculated.

The question was raised as to how feeble the magnetic intensity might be without preventing the getting of good observations; and Mr. Boys said he could make a spring balance which would do for delicate measurements of this sort, by rolling a quartz fibre into a spiral; and that by the use of a torsion arm an inch long, suspended by his finest fibres, he could detect a force of the million millionth of the weight of a grain. These infinitesimal methods of Mr. Boys tend to revolutionise all physical measurement, and to render possible an examination into the properties of substances over a very surprising range.

It may perhaps be remembered in this connection that the writer has observed that substances magnetic for feeble forces sometimes become diamagnetic for strong forces, especially when the substance is not homogeneous; and that all substances, or at least a great many, show traces of permanent magnetism when they have been subjected to strong fields.

Prof. Barrett exhibited the now well-known Gore effect in iron and steel, and told us more about his discovery of recalescence. It appears as if recalescence were going to abandon Section A altogether, and turn out to be a mere chemical process, viz., a sudden combination of iron and carbon when a certain temperature is reached in the cooling process, with consequent evolution of heat, expansion, and everything else that has been observed. Similarly, during heating, dissociation of iron and carbon at nearly the same stage will occur, with consequent cooling and momentary contraction. The one effect which appears to resist this barbarous chemical explanation is the sudden loss of magnetic polarity at the same critical point; and for a comprehension of this I hope we may have to look to Prof. Ewing's model, without help from Section B.

Mr. Trouton wishes to give us yet another physical constant to measure, which he calls the *co-efficient of abrasion* of bodies. At present the hardness of minerals is tested and recorded in a very primitive fashion by seeing which of them get scratched against which. To get a numerical measure and to avoid the arbitrariness of abrasion by a foreign body, Mr. Trouton proposes to grind two surfaces of the same material over each other at a known speed for an observed time under a measured intensity of pressure, and to collect and weigh the abraded material. The co-efficient of abrasion, which will not, indeed, be exactly "hardness," but which will be a definite thing, can then be defined as $\frac{p\ s}{m}$; where m is mass of substance rubbed off an area A, under a total pressure p A, during the time the surfaces have travelled a distance s over one another.

Mr. Trouton also described some further experiments he had made on the index of refraction of bodies to large-waved radiation; using the method of interposing a slab of the substance in the stationary waves caused by a reflector and observing the shift in the position of the nodes and loops thus caused. But there are many difficulties in the making of these experiments, partly owing to diffraction phenomena caused by the necessarily small size of the reflectors and slabs employed (small, that is, compared with the size of the waves), partly owing to reflection from the faces of the slab; for though it may be thought that reflection from the back will practically annul that from the front, it is not altogether so (owing, apparently, to absorption), and disturbing reflections do exist. Another difficulty is the perennial one of not being able to determine the position of the nodes with sharpness. For it must be remembered that even in a parallel beam of this kind of evanescent radiation the intensity of direct and reflected portions will not be the same. That which has travelled furthest has been longest subjected to damping influence, and accordingly, superposed upon the stationary waves, a set of progressive waves will be advancing uninterfered with by reflection.

Another more abstruse difficulty attending all the hitherto made slab or prism or lens determinations is the one mentioned above in connection with du Bois' experiments on metal films, viz., that the thickness of the substance is far too nearly comparable with the wave length of the radiation employed for ordinary optical theories to apply with ease and certainty.

The electrolytic discussion in Section A on Saturday, and in Section B on Monday, was, as it happened, of mainly chemical interest; and to give any intelligible account of it, it would be necessary to introduce the subject in a somewhat elaborate manner, and the result might not be well adapted to the nature of this article. The discussion is to be printed *in extenso* in the annual volume of the Association, under the editorship of Prof. Thorpe, and at some later date I shall hope to have something to say about it.

An excellent and very practical arrangement for obtaining lantern photographs in an easy and expeditious manner was exhibited by Profs. Barr and Stroud, who seem to have brought this sort of thing to perfection. But the details are easy to understand, and the apparatus will be purchasable before long, so that there is no need to dwell upon it.

A good many more Papers were read, but I did not hear them all; for though the Section at present declines to adjourn for lunch, I have at length learned that at a certain hour of the day nothing but lunch is worth discussing, and, moreover, that lunch cannot be taken effectively in a vitiated atmosphere, with the noise of a Paper which one is endeavouring not to heed surging in one's ears. If the Section suspended itself at one, there would be no hardship in sitting again from two to four, or even till five; but three hours' continuous session is enough for ordinary mortals, and after four hours' session communications cease to be effective; they become, indeed, anti-effective.

MAGNETISM IN IRON AND OTHER METALS.*—XXXI.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 483.*)

§ 115. Effects of Temperature within the Atmospheric Range.—None of the three magnetic metals is sufficiently affected by temperature to have its magnetic susceptibility very materially altered by any change of temperature that is liable to be experienced within the atmospheric range. In the case of iron, especially, the effects which atmospheric fluctuations of temperature exert upon the magnetic quality are too slight to require to be taken account of in specifying the magnetic properties of a sample, or in stating the results of experiments. Even when iron is raised to 100°C. the influence of the heating is by no means considerable. This is shown in Fig. 88, which gives two pairs of

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curves of I and H, one referring to iron wire in the soft annealed state, and the other to the same wire after it had been hardened by stretching beyond the limit of elasticity.* The full line in each pair is a curve of magnetisation taken at atmospheric temperature (7° or 8°C. in this case), and the dotted line is a curve of magnetisation taken while the wire was maintained at a temperature of 100°C. by enclosing it in a tube through which a current of steam was kept up. The curves cross at much the same value of I for both conditions of the metal, though at very different values of H.

§ 116. **Effects of Varying Temperature, the Magnetic Force being Constant.**—In the experiments which have been noticed above, the temperature was kept constant and the magnetic force was varied. If we keep the force constant and vary the temperature, a rather complex series of effects will be observed. In the first place, there is in general an effect which is not reversible—that is to say, which would not be undone if the temperature were brought back to its initial value. The first effect of any heating is like the effect of vibration: it produces a permanent change in the magnetisation; but whether that change will be an increase or a decrease will depend on the previous history of the magnetised piece. The reason of this should be apparent when we come to discuss molecular theories of induced magnetism: in effect it is this, that at any (not on account of complications proceeding from magnetic hysteresis, it is not possible to infer, from results of experiments of the one kind, where the reversal should occur in the other.

That the first effect of any change of temperature on the magnetism of iron or steel is not reversible has been shown by many experiments, probably first by those of Wiedemann.* If the magnetism that is dealt with is residual, and there is no acting magnetic force, a cyclic process of heating and cooling, or of cooling and heating, results in a reduction of the magnetism. If, on the other hand, the magnetism that is dealt with is that which has been reached by applying a magnetising force which is kept in action while the temperature is changed, then a cyclic process of heating and cooling or of cooling and heating results in an increase of magnetism. In either case it is, in general, only after many repetitions of the temperature cycle that the change of magnetism becomes cyclic. In the earliest cycles we find, superposed upon what may be called the legitimate or differential variations of magnetism, a progressive shaking in of magnetism if that is induced, or a progressive shaking out of magnetism if that is residual. By repeating the temperature cycle often enough we may get rid of the progressive changes, and may then study the differential effects of heating and cooling. One or two experiments of this class will be briefly referred to.

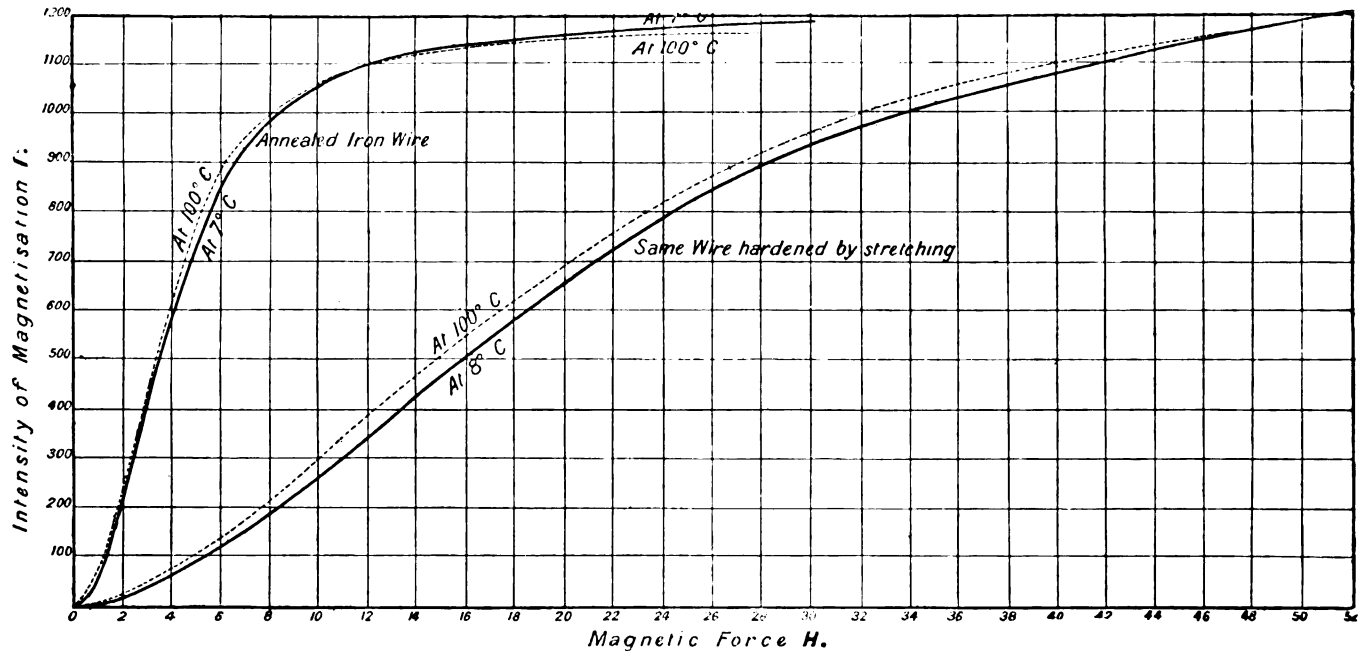

Fig. 88.—Effects of heating to 100° C. on the magnetic susceptibility of soft and hard iron.

extreme) stage in the process of magnetisation there are groups of molecules verging on instability, which are precipitated into instability when the temperature begins to change. This effect is distinct from—and may be much greater than—the reversible changes of magnetism which are caused by alternate heating and cooling. But when any alternation of heating and cooling is sufficiently often repeated, a cyclic *régime* is established; the magnetism will then fluctuate between two values, but whether the higher or the lower value will correspond to the hotter state will depend on whether the magnetism is below or above a certain value. In other words, the effects of temperature, when tested in this way (by repeated alternate heating and cooling), become reversed when the magnetisation is sufficiently strong. When there is but little magnetisation heating augments, and cooling reduces the amount of magnetism, whether that be either residual, or induced by the action of a constant magnetising force; when there is much magnetisation the reverse happens. The reversal of effect which is observed in experiments of this class is evidently to be anticipated in connection with the crossing of the magnetisation curves in experiments of the class described above. But,

* Phil Trans., 1885, p. 637.

§ 117. **Experiments in Alternate Heating and Cooling of Magnetised Iron.**—In the first of these† a hardened iron wire was tested, surrounded by a tube, on which a magnetising coil was wound, and through which currents of steam or of cold water could be alternately passed. The resulting magnetic changes were observed by means of a magnetometer. The wire was at first demagnetised, and then from time to time its magnetism was increased a step by passing a weak current through the magnetising coil; but after each such step the current was stopped, and the only force in action was the vertical component of the earth's field. The first series of heatings and coolings (between 100° C. and 6° C.) made I fluctuate between about 2·14 (cold) and 2·23 (hot). At this stage heating increased I. Later the fluctuations of I were from 3·51 (cold) to 3·56 (hot); the effect still had the same sign. Later still it became reversed; the fluctuations of I were between 8·69 (cold) and 8.67 (hot), and later still the reversed effect was more marked, the range being from 9·09 (cold) to 9·04 (hot).

A similar experiment with a piece of annealed iron wire‡ showed that the reversal of effect took place in that case when

* "Galvanismus," II., § 522 *et seq.*
† *Phil. Trans.*, 1885, p. 633. ‡ *Loc. cit.*, p. 635.

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I was about 20. At an early stage I ranged from 4·77 (at 6°C.) to 4·95 (at 100°C.); at a later stage (after reversal) I ranged from 37·53 (at 6°C.) to about 36·77 (at 100°C.). In both cases the reversal occurred at a very early point in the process of magnetisation.

In another case * the magnetisation of the specimen was examined at intermediate points, during heating and during cooling, to see whether there was hysteresis in the relation of magnetism to temperature. The specimen—a long iron wire—was fixed inside a glass tube which could be connected at one end to any one of three small boilers capable of supplying a steady current of steam, of alcohol vapour, and of sulphuric ether vapour, or to a cistern supplying cold water. Steam and cold water (at 14°C.) were alternately passed through the tube many times until the magnetic state of the wire was observed to change from one to the other of two nearly steady values. Then readings of the magnetometer were taken during the passage through the tube of (1) cold water, (2) ether vapour, (3) alcohol vapour, (4) steam, (5) alcohol vapour, (6) ether vapour, (7) cold water. This completed a cycle of temperature changes in which two intermediate points (35°C. and 78½°C.), were fixed during the process of heating and cooling. The method was adopted in order to secure that the iron should be exposed sufficiently long to an atmosphere of definite temperature to give it time to take that temperature throughout, and so avoid any possibility of error proceeding from the sluggishness with which changes of temperature take place. The stream of vapour was kept up in every case until the magnometer reading became steady.

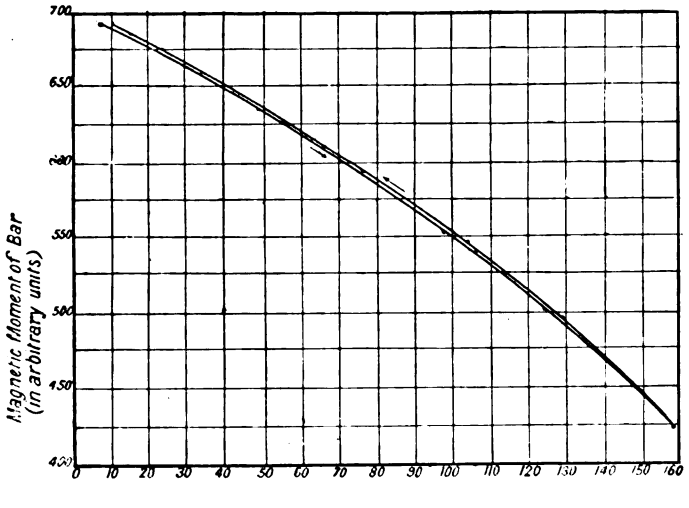

Fig. 89.—Effects of heating and cooling a steel bar magnet.

The iron was magnetised to begin with sufficiently strongly to make the heating cause a diminution and cooling an augmentation of magnetism. The only magnetic force in action during the heating and cooling was the earth's vertical field. In the following statement of observed results the numbers are proportional (on an arbitrary scale) to the intensity of magnetisation. The arrows show the sequence of the changes:

	Water.		Ether vapour.		Alcohol vapour.		Steam.
Temp.	14°C.		35°C.		78½°C.		100°C.
	17,416	→	17,382	→	17,304	→	17,262
	17,418	←	17,382	←	17,304	←	

The whole change is about 0·9 per cent. of the whole magnetism. It is clear from the readings at 35°C. and 78½°C. that the changes occur without any perceptible hysteresis; the magnetisation at intermediate points is, as nearly as can be judged, the same during heating as during cooling.

Fig. 89 shows the result of another experiment of the same class,† in which a steel bar magnet was heated and cooled in a bath of oil, through a considerably wider range of temperature (between 10°C. and 158°C.). The temperature of the oil was altered very slowly—so slowly that it took more than 17 hours to complete the cycle of changes shown in the figure—in order to let the bar's temperature be sensibly uniform with that of the oil, which was observed by means of two thermometers. Several heatings and coolings preceded the cycle in which the observations were made. Here, as in the former case, there is no sensible hysteresis in the relation of magnetism to temperature.

(To be continued.)

* *Loc. cit.*, p. 631. † *Loc. cit.*, p. 638.

ON THE ELECTRO-DYNAMICS OF STATIONARY BODIES.*

BY H. HERTZ.

(Continued from page 484.)

Electric and Magnetic Polarisation.—As far as our equations relate to an isotropic medium they give at any given moment the value of a physical quantity in terms simply of the actual state of things existing at the moment considered.

This form of the equations is very useful from a mathematical point of view, because it shows at once the sequence of any phenomenon. This form is also perfect from a philosophical point of view, because it is possible to make the left-hand side of the equations represent the future state, while the cause of this future, *i.e.*, the actual state, is represented on the right-hand side.

The analogous equations relating to non-isotropic bodies are far from exhibiting this perfect form, since their left-hand side does not consist of a derivative of a single physical quantity, but is a function of these derivatives. However, as these functions are linear it is easy to put the equations into the desirable form.

Another means conducting to the same end consists in the introduction of new quantities, which may be called components of polarisation. These quantities are,

$$\left.\begin{aligned} L_p &= \mu_{11}L + \mu_{12}M + \mu_{13}N \\ M_p &= \mu_{21}L + \mu_{22}M + \mu_{23}N \\ N_p &= \mu_{31}L + \mu_{32}M + \mu_{33}N \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (7)$$

$$\left.\begin{aligned} X_p &= \epsilon_{11}X + \epsilon_{12}Y + \epsilon_{13}Z \\ Y_p &= \epsilon_{21}X + \epsilon_{22}Y + \epsilon_{23}Z \\ Z_p &= \epsilon_{31}X + \epsilon_{32}Y + \epsilon_{33}Z \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (8)$$

Except for crystalline bodies, the quantities having two different suffixes are each zero; and probably for all substances quantities having the same two suffixes (such as ϵ_{12} and ϵ_{21}) are equal to each other.

We shall call the resultant of L_p, M_p and N_p the magnetic polarisation, and, similarly, the resultant of X_p, Y_p and Z_p we shall call the electric polarisation. For isotropic media the forces and polarisations lie in the same direction, and their ratio, according as we are considering magnetic or electric phenomena, is either the magnetic constant μ or the dielectric constant ϵ. For free ether the forces and polarisations are identical. If we introduce these quantities into the first members of our equations we shall see that the variation of each component of the polarisation depends directly on the forces at the instant considered. As the forces are themselves linear functions of the polarisation components we can easily introduce the latter into the second members of the equations. We shall then have replaced the directed quantities serving to specify the electro-magnetic state, viz., the electric and magnetic forces, by other directed quantities defining the polarisation. These latter serve the same purpose as the former, but are more useful to consider. Since the equations are simplified by the introduction of the polarisation components besides those of the forces, we shall make the assumption that with massive bodies it is necessary to have given two directed magnetic quantities and two directed electric quantities in order to completely specify the electro-magnetic state of the medium.

* An abstract of a paper published in the "Nachrichten von der Kœniglichen Gesellschaft, der Wissenschaften," for March, 1890 and reprinted in *La Lumière Électrique*, July, 1890.

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In order to further simplify our equations let us put—

$$\left.\begin{aligned} u &= \lambda_{11}(X-X') + \lambda_{12}(Y-Y') + \lambda_{13}(Z-Z') \\ v &= \lambda_{21}(X-X') + \lambda_{22}(Y-Y') + \lambda_{23}(Z-Z') \\ w &= \lambda_{31}(X-X') + \lambda_{32}(Y-Y') + \lambda_{33}(Z-Z') \end{aligned}\right\} \quad . \quad (9)$$

Here, as before, with the exception of crystalline bodies, coefficients having different suffixes are each zero, and also for all known bodies, $\lambda_{13}=\lambda_{32}$, $\lambda_{31}=\lambda_{13}$, $\lambda_{12}=\lambda_{21}$.

Our general equations (1) and (6) then take the definite form—

$$\left.\begin{aligned} A\frac{dL_p}{dt} &= \frac{dZ}{dy} - \frac{dY}{dz} \\ A\frac{dM_p}{dt} &= \frac{dX}{dz} - \frac{dZ}{dx} \\ A\frac{dN_p}{dt} &= \frac{dY}{dx} - \frac{dX}{dy} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$\left.\begin{aligned} A\frac{dX_p}{dt} &= \frac{dM}{dz} - \frac{dN}{dy} - 4\pi A u \\ A\frac{dY_p}{dt} &= \frac{dN}{dx} - \frac{dL}{dz} - 4\pi A v \\ A\frac{dZ_p}{dt} &= \frac{dL}{dy} - \frac{dM}{dx} - 4\pi A w \end{aligned}\right\} \quad . \quad . \quad (11)$$

and the electro-magnetic energy per unit volume of any body whatever is given by the expression

$$\frac{1}{\pi}(X X_p + Y Y_p + Z Z_p) + \frac{1}{8\pi}(L L_p + M M_p + N N_p). \quad (12)$$

These expressions are true for bodies of all kinds, whether crystalline or not.

From what we have established in the preceding sections, we conclude that u, v, and w are the components in electrostatic measure of the electric current.

Electricity and Magnetism.—Let us consider the electro-magnetic phenomena occurring within a material system which is completely separated from the influences of external bodies. Differentiate the three equations (11) by x, y, and z respectively and add; we obtain

$$\frac{d}{dt}\left(\frac{dX_p}{dx}+\frac{dY_p}{dy}+\frac{dZ_p}{dz}\right) = -4\pi\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{d\omega}{dz}\right) \quad . \quad . \quad (13)$$

Let us integrate each side of this equation throughout the space bounded by any closed surface completely enveloping the system. Let $d\tau$ be an element of volume, and $d\omega$ an element of the surface whose normal makes with the axes the angles (n, x), (n, y), and (n, z). Then, by a theorem well known to mathematicians, we have

$$\int\left(\frac{dX_p}{dx}+\frac{dY_p}{dy}+\frac{dZ_p}{dz}\right)d\tau = \int [X_p \cos(n,x) + Y_p \cos(n,y) + Z_p \cos(n,z)]\, d\omega \quad . \quad . \quad (14)$$

and

$$\int\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{d\omega}{dz}\right)d\tau = \int [u\cos n, x) + v\cos(n,y) + \omega\cos(n,z)]\, d\omega \quad . \quad . \quad (15)$$

and as at the surface the values of u, v, ω, are zero, we have

$$\frac{d}{dt}\int\left(\frac{dX_p}{dx}+\frac{dY_p}{dy}+\frac{dZ_p}{dz}\right)d\tau = 0.$$

So that if we integrate with respect to t we obtain

$$\int\left(\frac{dX_p}{dx}+\frac{dY_p}{dy}+\frac{dZ_p}{dz}\right)d\tau = 4\pi e \quad . \quad . \quad (16)$$

where e is some quantity independent of time t. This quantity e here introduced is evidently a function of the electrical state of the system, and is such that its magnitude cannot be increased or diminished by any electro-magnetic phenomena occurring either within or without the system under consideration. This property of invariability points very strongly to the belief that a quantity of a definite substance contained within the system is represented by its value; and in conformity with this view we shall call e the quantity of electricity contained within the material system. As the quantity e may be either positive or negative we may suppose it to represent the excess of electricity actually contained within the system over the quantity normally comprised within it.

Whatever form the quantity e may actually take, each element of volume $d\tau$ contributes to the total value an element whose magnitude is given by the expression

$$\frac{1}{4\pi}\left(\frac{dX_p}{dx}+\frac{dY_p}{dy}+\frac{dZ_p}{dz}\right)d\tau$$

and we shall call the quantity thus represented the "true" electricity of the element. The "true" volume density within a body is thus equal to

$$\frac{1}{4\pi}\left(\frac{dX_p}{dx}+\frac{dY_p}{dy}+\frac{dZ_p}{dz}\right) \quad . \quad . \quad . \quad . \quad (17)$$

while at the bounding surface of a body the "true" surface density is equal to

$$\frac{1}{4\pi}[(X_{p,2}-X_{p,1})\cos(n,x) + (Y_{p,2}-Y_{p,1})\cos(n,y) + (Z_{p,2}-Z_{p,1})\cos(n,z)]$$

For free space the quantities representing the forces and polarisations coincide, so that we may replace the above expressions by others in which the suffixes p are removed. To distinguish the new expressions for surface and volume density, we shall suppose them to relate to "free" electricity. In air and open space the amount of "free" electricity is the same as the amount of "true" electricity, but in material bodies the latter exceeds the former by a quantity which, in accordance with old notions, may be styled "bound" electricity.

In accordance with the foregoing reasoning, the quantity of "true" electricity on a surface (whether closed or unclosed) is obtained by integrating the expression

$$\frac{1}{4\pi}\int [X_p \cos(n,x) + Y_p \cos(n,y) + Z_p \cos(n,z)]\, d\omega$$

over the surface considered. We shall say that this expression is equal to the total number of lines of force cut by the surface in the direction of the normal drawn positively. This definition is in accordance with Faraday's suppositions that the lines of force point always in the direction of the acting force, and are in density proportional to the magnitude of the force. We shall complete the suppositions and at the same time make them more accurate by assuming that the lines of force in any body proceed in the direction not of the *force* but of the *polarisation*, and that their density is proportional to the magnitude of the polarisation. It follows from these definitions that 4π times the quantity of true electricity contained in any given volume is equal to the difference between the number of lines of force arriving at the bounding surface and those leaving it. Each end of a line of force represents a certain quantity of "true" electricity, and we can specify the quantity of this electricity by the number of free ends of the lines.

If some space situated in the neighbourhood of the surface, over which the integral is calculated, is quite devoid of "true" electricity, the value of the integral is entirely independent of the particular shape and position of the surface throughout the space in question, and depends simply on the contour of the surface. In such cases we shall say that the value of the integral is equal to the number of lines of force enclosed by the contour, without reference to the shape of the surface bounded by it.

The rate at which the quantity of "free" electricity e increases within a given space can be obtained from (13) and (16), and is given by the expression

$$\frac{de}{dt} = -\int\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{d\omega}{dz}\right)d\tau$$

$$= -\int [u\cos(n,x) + v\cos(n,y) + \omega\cos(n,z)]\, d\omega \quad . \quad . \quad (18)$$

by (15).

Now, if the region at the bounding surface is non-conducting, the conductivities λ are zero, and from (9) it follows that $u=v=\omega=0$; so that from (18) we see that $\frac{de}{dt}=0$, and that in consequence the quantity of "true" electricity within the space considered remains absolutely constant. Electricity cannot, therefore, escape from a body surrounded by a medium

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for which the quantities λ are zero. It is for this reason that we call such a medium non-conducting. If at any part of the bounding surface a body exists for which the quantities λ are not zero, variation of the electricity is possible; and hence such a body is called a good conductor in contrast with bad conductors within which electrical movement is only possible under the influence of electro-dynamic phenomena. The division of bodies into good and bad conductors only then refers to "true" electricity; with respect to "free" electricity, all bodies can be considered conducting, since polarisation currents are transmitted by them.

The quantity of a substance within a given volume can only vary by the entrance or exit of a certain quantity of it through the bounding surface of the space considered; and each element of the bounding surface must pass a quantity, whose amount is perfectly determinate. In accordance with this axiom we may assume that the quantity of electricity per second (the electric current) crossing unit surface of each element is equal to

$$u\cos(n,x)+v\cos(n,y)+w\cos(n,z) \quad . \quad . \quad (19)$$

and the integral of this taken over any surface is equal to the current flowing across this surface. We must remark that, even admitting the material nature of electricity, the special way in which we have obtained the electric current constitutes a great assumption. We can, in fact, to the system of currents found, superpose any closed system of currents without varying in the slightest degree the rate of increase or decrease at a given point.

If a part of the system can pass from the electrified to the non-electrified state, and *vice versâ*, under the sole influence of electro-magnetic phenomena, the amount of true electricity in each of the non-conductors is zero, and in consequence the quantities represented by the expressions (16 and 17) are each equal to zero for such bodies.

The same considerations that we have put forward for electrical phenomena can equally well be applied to magnetic phenomena. In fact, in the foregoing expressions we have merely to replace X, Y, and Z respectively by L, M, and N. Thus, the "true" magnetic volume and surface densities are given by the expressions

$$\frac{1}{4\pi}\left(\frac{d\,L_p}{d\,x}+\frac{d\,M_p}{d\,y}+\frac{d\,N_p}{d\,z}\right) \quad . \quad . \quad . \quad . \quad (20)$$

and,

$$\frac{1}{4\pi}\{(L_{p,2}-L_{p,1})\cos(n,x)+(M_{p,2}-M_{p,1})\cos(n,y)+(N_{p,2}-N_{p,1})\cos(n,z)\} \quad . \quad . \quad . \quad . \quad (21)$$

Again, the number of magnetic lines of force traversing a surface is given by the surface integral

$$\int\{L_p\cos(n,x)+M_p\cos(n,y)+N_p\cos(n,z)\}\,d\omega \quad . \quad (22)$$

and by leaving out the suffixes p we get expressions which refer to "free" magnetism.

The distinction of bodies into good and bad conductors does not, however, occur for "true" magnetism, since equations (10) do not contain any conduction terms to correspond with equations (11). With regard to "free" magnetism, all bodies can be considered conducting as in the analogous electrical case. If a system, or a part of a system, can pass from its magnetic to its non-magnetic state, and *vice versâ*, by purely electro-magnetic means, the expressions (20) and (21) for volume and surface density can each be equated to zero.

(To be continued.)

THE EFFECT OF DIRECT AND ALTERNATING PRESSURES ON THE HUMAN BODY.*

BY J. SWINBURNE.

As there seems to be some doubt as to the relative effects of alternating and direct currents, a bridge which measured the resistance of the patient under various pressures was made up. Fuller readings, which agreed with the first as nearly as such very uncertain readings can be expected to agree, were afterwards taken by putting on different pressures and measuring the current; the resistances being calculated. The alternating currents were measured with a non-inductive wattmeter arranged as an ammeter, the pressure being taken with a hot wire voltmeter. The tests were taken from hand to hand, the hands being dry or wet with dilute acid in the case of direct currents, and dry in the case of alternating. It seemed to make little difference in the case of alternating currents whether the hands were wet or dry. There was no need to measure the resistance from hand to foot, as that obviously would depend on the boots worn.

Human Resistances; Hand to Hand.

Current.	Name.	Hands.	Volts.	Resistance.
Alternate	A	Dry	18	950
Continuous	,,	Dry	50	8,000
Continuous	,,	H_2SO_4	50	3,010
Alternate	B	Dry	10	1,330
Alternate	,,	Dry	18	1,110
Continuous	,,	Dry	50	6,6[illegible]0
Continuous	,,	H_2SO_4	50	1,930
Alternate	C	Dry	18	620
Continuous	,,	Dry	50	5,4[illegible]0
Continuous	,,	H_2SO_4	50	1,[illegible]80
Alternate	D	Dry	18	1,090
Continuous	,,	Dry	50	10,000
Continuous	,,	H_2SO_4	50	16,000
Continuous	E	Dry	50	6,700
Continuous	,,	H_2SO_4	50	1,100
Alternate	,,	Dry	18	1,300
Alternate	F	Dry	18	750
Continuous	,,	Dry	50	3,320
Continuous	,,	H_2SO_4	50	1,710
Alternate	,,	Dry	54	670

In the above table the direct pressure is always 50 volts. Any of those tested could have taken more than this; but even with 50 volts the discomfort is extreme if the contact is made and broken. The maximum current taken was ·04 ampere by E, whose resistance is low. He could have taken more if available. All the resistances are much lower than those obtained by the usual method of measuring with a bridge and one or two cells. Probably polarisation then interferes.

When the direct current from 50 volts is concentrated in one finger it feels hot, though especially as the current is reduced, there can be no appreciable heat generated.

The most curious thing is the very low effective resistance to alternating currents. The alternating pressure could be regulated by steps of 4·5 volts. Out of the five subjects tested not one except F could stand more than 18 volts alternating, the maximum effective current taken being ·03 ampere. F seems abnormal. He took 54 volts and nearly a tenth of an ampere. D, who has the highest resistance, was the only lady tested. Though, with the exception of F, none of us could take more than 18 volts alternating with a good contact, I have several times touched 600-volt alternating terminals lightly. They were given by a Siemens machine used for "flashing" lamps. Before I took charge of the factory containing it I am told several of the girls had shocks from the same machine. Spring switches, which demanded both hands to give any current, obviated danger to them afterwards. I have also had a very severe shock from a 100-volt Ferranti. Though 18 volts was as much as we could take, there was no difficulty in letting go.

These results bear out those of Messrs. Lawrence and Harries* as to the relative resistance to alternating and direct currents, but the figures are entirely different. They never found anyone take over 10 milliamperes, while F took 90 milliamperes alternating, and E, a workman, took 44 milliamperes direct, and could have taken far more if available.

* Paper read before the British Association in Section A, Leeds September, 1890.

* *Jour.* Inst. Elec. Eng., XIX., No. 86. *The Electrician*, April 4, 1890, p. 557.

The Telephonic Transmission of Music.—The Emperor of Germany recently regaled the Emperor of Austria at the Castle of Rohnstock with selections from "Carmen" and other operas transmitted by telephone from the Berlin Opera House, a distance of 250 miles.

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The Electrician.

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	s. d.	s. d.	s. d.
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For Foreign Parts and Colonies:—			
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ELECTRICAL PROGRESS.

The industrial applications of electricity are at the present day so various and important that the pseudo-scientific novelist who is endowed with a sufficiently vivid imagination may be certain of producing a saleable work by the simple process of magnifying to the power of six the present applications of electricity and dating his lucubration 1990, or by partially inverting the process and drawing harrowing pictures of what would happen if electricity were suddenly to disappear from our everyday life. Without, however, rising to the height of all the superlatives usual on such occasions, a glance at some of the recent advances of industrial electricity and a brief mention of one or two of its more promising future developments may not be out of place at a season of the year when those whose business it is to supply materials for discussions at the meetings of scientific societies are silent and presumably engaged in recruiting their exhausted frames for the Session of 1890-91.

Across the Atlantic electric lighting shows distinct signs of the near approach of the crystalline stage. Outdoor wiring, indeed, it is generally admitted, still affords room for improvement, and perfection is not yet claimed even for American dynamos; but it is felt that the work of distributing current for the purposes of light and power is fast settling down into a few regular grooves, and that nothing very novel need be looked for in that direction. A glance at the voluminous Papers read at any of the numerous electrical conventions shows tolerably plainly that the improvement of details and not the introduction of novelties has now become the chief business of American electric light engineers. Even with us central stations are beginning to lose the interest of novelty; and the last fine crop of Provisional Orders, making all due allowances for non-performance, cannot but result in still further hastening the process. What exactly will be the outcome of the sudden fervour with which our Local Authorities have adopted the motto of "the electric light for the people" remains to be seen; but, that street lighting on a comparatively extensive scale will be indulged in in many of our most important towns seems highly probable. The glare, flickering, and glorious uncertainty of "pioneer" arc lighting would have been sufficient to have destroyed the reputation of a much finer means of illumination; and it is by no means surprising that the British mind, while forced to admit the beauty of incandescent lighting, still draws the line at the arc lamps. But arc lighting with the best modern lamps,

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carbons, lanterns, and dynamos, and employed in the lavish style that only a municipality performing a public duty may aspire to, should not take long in conquering a place for itself and becoming the recognised light for the main streets and open spaces of our dimly-lighted cities. The battle of the systems (then largely on paper) which raged so furiously but two years ago, has now subsided; and the many doughty champions who formerly confronted one another across the arena at 25, Great George-street have possibly in many instances considerably modified their views, and are busily engaged in carrying out high and low tension work according as local circumstances and peculiarities favour the one or the other. In the States, house lighting is practically carried out on either the alternate-current transformer or the three-wire system; and the limitations of these two methods are now, as with us, pretty well ascertained. Neither storage-batteries nor continuous-current transformers have, on the other hand, met with much vogue across the ocean. Tardy, therefore, as has been our commencement of serious central lighting work, it has been left to English electrical engineers to put to the test the capabilities of distribution by means of storage-battery sub-stations at Chelsea, and to ascertain the value of continuous-current transformers at St. Pancras. The former system has already shown itself equal to the fulfilment of the elementary requirements of constancy of pressure and freedom from breakdown, and it only remains for a few more facts to be ascertained as to its economy for it to take its appropriate place amongst the recognised methods of distributing the electric current. Distribution by means of continuous-current transformers is at the present moment completely *in futuro*, and it has yet to exhibit its superiority in some one particular over the systems at present in use. It has thus the distinction of being still an open question, and one which has not already been discussed to exhaustion in the technical press and at electrical societies.

But if the distribution of electricity for light and power has become a comparatively prosaic routine performance, we are not left entirely without compensation, for again our progressive cousins are showing us the way, to their honour and our advantage. The conditions in this country are not over favourable to electrical experiments of any description. What better could happen, therefore, than that the many knotty problems connected with electric traction should be partially solved for us across the Atlantic? In a few years it will doubtless have been satisfactorily settled for us by practical experience whether we should employ two small motors or a single large machine; and an efficient slow-speed motor geared direct to the axle will probably have been evolved. With such points disposed of, and the City and South London line and the Liverpool Overhead Railway in fair running order, it is possible, provided that a satisfactory closed or open conduit system has been devised, that we may buckle to and move forward in the matter of electrical propulsion.

Owing doubtless to the attention which has of recent years been paid to the development of telegraphy, telephony, the distribution of electricity for the purposes of light and power, and electric traction, the minor applications of electricity have until quite lately scarcely received their due attention. All this is now, however, rapidly being altered; and no doubt as the larger applications become more or less worked out increased energy will be expended in developing the potential possibilities of electricity in other directions. Electric bleaching, electric tanning, and electric welding have, as the saying is, "come to stay;" and even electric heating, although under present conditions it can scarcely be termed economical, may, it is quite conceivable, under special conditions, have advantages outweighing its disadvantages. An electric heater, it must be remembered, can be almost instantly lit and extinguished, and probably in the event of any accident it would be put out by the very occurrence of the accident. Further advantages arise from its almost absolute cleanliness and the complete absence of deleterious gases, and these manifest advantages have already led to its adoption on several American railways. The electrical dissipation of fog, of which something was heard in these columns a few months ago, is not indeed as yet an accomplished fact, but we believe that something similar has been tried with a certain measure of success in the case of the fumes given off in lead factories where considerable loss of lead occurs in this way.

The application of electricity to agriculture and horticulture in which so much interest was excited by the well-known experiments of Sir William Siemens in 1880-81, has lately had attention again drawn to it by the remarkable results obtained in Russia by Specnew. Sir William Siemens, it will be remembered, investigated the effect of exposing various plants placed inside a glasshouse to the electric light during the night time, and found that while a naked arc light produced anything but satisfactory results, the interposition of a mere thin sheet of clear glass between the plants and the source of light was most striking. Peas sown at the end of October produced a harvest of ripe fruit by the middle of February; strawberry plants planted about the middle of December produced excellent fruit two months afterwards, and equally satisfactory results were obtained with wheat, barley, and oats. "It is with great diffidence, and without wishing to generalise," says Sir William Siemens, "that I feel bound to state as the result of all my experiments, extending now over two winters, that although periodic darkness evidently favours growth in the sense of elongating the stalks of plants, the continuous stimulus of light appears favourable for healthy development at a greatly accelerated pace through all the stages of the annual life of the plant, from the early leaf to the ripened fruit. The latter is superior in size, in aroma, and in colour to that produced by alternating light, and the resulting seeds are not, at any rate, devoid of regerminating power."

Specnew's experiments, which extended over five years, were of a different order. He first of all investigated the effect of submitting different seeds to the direct action of an electric current, and he then carried out two series of experiments on a large scale. In one set of experiments he placed zinc and copper plates of 3½ square feet in the soil and connected them overhead by insulated wires, forming in this way a zinc | earth | copper cell. The plots between the plates he planted with various seeds. In the other series of experiments he employed a number of insulating rods crowned with comb collectors. All Specnew's experiments showed that electricity had a beneficial effect, and the increased yield due to electro-culture as compared with that due to ordinary culture on identically the same soil amounted in some instances to over 200 per cent. Specnew, although he did not make economy his primary object, seems to have obtained those results at a cost comparable, say, with that of ordinary fertilising agents, £10 per acre being the cost of his insulating rod apparatus. The minor applications of electricity bid fair, therefore, to assume large proportions; and the danger seems to be not that they will be neglected, but that too much will be expected of them. The law of the conservation of energy is now fortunately well understood and is always with us. Were it not so we should doubtless see many a limited company floated in the city of London for the purpose of obtaining 100 horse-power electrically by the expenditure of 10 mechanically.

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ELECTRIC LIGHTING NOTICES FOR 1890-91.

The following is a list of the Local Authorities who have been served with notices by Electric Lighting Companies for the ensuing year. In places marked with an asterisk (*) the Local Authorities have decided themselves to apply for an Order or Licence, or are considering the advisability of doing so.

Place.	No. of Applications.	Names of Applicants.
METROPOLITAN AREAS.		
Acton	1	House-to-House Electric Light Supply Company.
Battersea	1	House-to-House Electric Light Supply Company.
Camberwell ...	3	Electric Installation and Maintenance Company. House-to-House Electric Light Supply Company. London Electric Supply Corporation.
Chelsea	4	Kensington and Knightsbridge Electric Lighting Co. London Electric Supply Corporation. New Cadogan and Belgrave Electric Supply Co. Westminster Electric Supply Corporation.
Chiswick.....	1	House-to-House Electric Light Supply Company.
City of London	3	House-to-House Electric Light Supply Company. Laing, Wharton, and Down Construction Syndicate. Metropolitan Electric Supply Company.
Fulham	4	Brush Electrical Engineering Company. House-to-House Electric Light Supply Company. London Electric Supply Corporation. Stamford Hill, Tottenham and Edmonton Electric Light and Power Supply Company.
Hackney.....	1	House-to-House Electric Light Supply Company.
Hammersmith...	1	House-to-House Electric Light Supply Company.
Hampstead.....	2	House-to-House Electric Light Supply Company. Metropolitan Electric Supply Company.
Hornsey	1	House-to-House Electric Light Supply Company.
Kensington.....	2	Kensington and Knightsbridge Electric Lighting Co. Westminster Electric Supply Corporation.
Lambeth	3	House-to-House Electric Light Supply Company. London Electric Supply Corporation. Metropolitan Electric Supply Company.
Paddington.....	4	Kensington and Knightsbridge Electric Lighting Co. London Electric Supply Corporation. Paddington and Bayswater Electric Light and Power Company. Westminster Electric Supply Corporation.
Shoreditch	1	House-to-House Electric Light Supply Company.
St. George's (Hanover-sqre.)	4	Chelsea Electricity Supply Company. New Cadogan and Belgrave Electric Supply Co. Kensington and Knightsbridge Electric Lighting Co. St. James and Pall Mall Electric Light Company.
St. George-the-Martyr (Southwark)	1	London Electric Supply Corporation.
St. John and St. Margaret (Westminster)	1	Westminster Electric Supply Corporation.
St. Luke's	2	House-to-House Electric Light Supply Company. London Electric Supply Corporation.
St. Marylebone	1	Westminster Electric Supply Corporation.
St. Pancras ...	1	Metropolitan Electric Supply Company.
Wandsworth ...	2	House-to-House Electric Light Supply Company. Metropolitan Electric Supply Company.
Whitechapel ...	1	House-to-House Electric Light Supply Company.
Willesden	1	House-to-House Electric Light Supply Company.
Woolwich	2	Woolwich District Electric Light Company. London Electric Supply Corporation.
PROVINCES.		
Alnwick	1	Northern Counties Electric Light and Power Supply Company.
Altrincham.....	1	Manchester House-to-House Electricity Company.
Astley Bridge...	1	Lancashire and Cheshire House-to-House Electricity Company.
Aylesbury	1	Latimer Clark, Muirhead and Co.
Barrow-in-Furness	2	Lancashire and Cheshire House-to-House Electricity Company. Municipal Electric Light and Power Corporation.
Batley	1	Yorkshire House-to-House Electricity Company.
Birmingham ...	2	Birmingham Electric Supply Company. Birmingham House-to-House Electricity Co.
Blackrock	1	Irish House-to-House Electricity Company.
*Bolton	2	Lancashire and Cheshire House-to-House Electricity Company. Municipal Electric Light and Power Corporation.
Boston.....	1	Latimer Clark, Muirhead and Co.
Bowdon	1	Manchester House-to-House Electricity Company.
Bradford-on-Avon	1	Latimer Clark, Muirhead and Co.
Bristol	3	Bristol Electricity Supply Company. Laing, Wharton, and Down Construction Syndicate. Western House-to-House Electricity Company.
Broadstairs.....	1	Municipal Electric Light and Power Corporation.
*Bromley	1	Laing, Wharton, and Down Construction Syndicate.
Buxton	1	Municipal Electric Light and Power Corporation.
*Canterbury. ...	3	Brush Electrical Engineering Company. Canterbury Electricity Supply Company. South of England House-to-House Electricity Co.
*Cardiff	5	Barry and Cardiff Electric Light and Power Supply Company. Brush Electrical Engineering Company. Electric Installation and Maintenance Company. National Electric Supply Company. Western House-to-House Electricity Company.
Chesterfield ...	1	Laing, Wharton, and Down Construction Syndicate.
Cirencester.....	1	Latimer Clark, Muirhead and Co.
Colchester	1	Latimer Clark, Muirhead, and Co.
ComptonGifford	1	Devon and Cornwall Electricity Supply Company.
Cork	1	Irish House-to-House Electricity Company.
Coventry.....	2	Midland House-to-House Electricity Company. Municipal Electric Light and Power Corporation.
Crosshill	1	Scottish House-to-House Electricity Company.
Croydon	1	South of England House-to-House Electricity Co.
Darkley	1	Irish House-to-House Electricity Company.
Daventry	1	Latimer Clark, Muirhead and Co.
Derby	1	Laing, Wharton, and Down Construction Syndicate.
Devonport	1	Devon and Cornwall Electricity Supply Company.
Dewsbury	2	Latimer Clark, Muirhead and Co. Yorkshire House-to-House Electricity Company.
Didsbury.....	1	Manchester House-to-House Electricity Company.
Dorchester	1	Latimer Clark, Muirhead and Co.
Drogheda	1	Irish House-to-House Electricity Company.
Dudley	2	Midland House-to-House Electricity Company. Municipal Electric Light and Power Corporation.
Dukinfield (Lancs.)	1	Municipal Electric Light and Power Corporation.
Dundalk	1	Irish House-to-House Electricity Company.
Dundee	1	Scottish House-to-House Electricity Company.
Eastbourne ...	1	Eastbourne Electric Light Company.
East Cowes.....	1	Municipal Electric Light and Power Corporation.
East Stonehouse	1	Devon and Cornwall Electricity Supply Company.
Edinburgh	4	Latimer Clark, Muirhead and Co. National Electric Supply Company. Scottish Electric Supply Company. Scottish House-to-House Electricity Company.
*Exeter	2	Devonshire Electric Light and Power Supply Co. Exeter Electric Light Company.
Farnworth	1	Lancashire and Cheshire House-to-House Electricity Company.
Folkestone	1	South of England House-to-House Electricity Co.
Glasgow	1	Scottish House-to-House Electricity Company.
Gloucester	2	Municipal Electric Light and Power Corporation. Western House-to-House Electricity Company.
Govan	1	Scottish House-to-House Electricity Company.
Govanhill	1	Scottish House-to-House Electricity Company.
Gravesend	1	South of England House-to-House Electricity Co.
Guildford	1	South of England House-to-House Electricity Co.
Greenock	1	Scottish House-to-House Electricity Company.
Halifax	2	National Electric Supply Company. Yorkshire House-to-House Electricity Company.
Hampton Wick	1	Municipal Electric Light and Power Corporation.
Hanley (Staffs.).	2	Birmingham House-to-House Electricity Co. Brush Electrical Engineering Company.
Harborne	1	Birmingham House-to-House Electricity Co.
*Harrogate	2	National Electric Supply Company. Yorkshire House-to-House Electricity Company.
Hartlepool	1	Municipal Electric Light and Power Corporation.
Hawick	1	Scottish House-to-House Electricity Company.
Hebden Bridge	1	Latimer Clark, Muirhead and Co.
*Hertford	1	Hertford Electric Light and Power Supply Company.
Heywood (Lan.)	1	Municipal Electric Light and Power Corporation.
Hillhead	1	Scottish House-to-House Electricity Company.
Huddersfield ..	1	Yorkshire House-to-House Electricity Company.
Hyde	1	Midland House-to-House Electricity Company.
Ilkley	1	Yorkshire House-to-House Electricity Company.
Ipswich	1	Brush Electrical Engineering Company.
Jarrow.....	1	Municipal Electric Light and Power Corporation.
Kearsley	1	Lancashire and Cheshire House-to-House Electricity Company.
Keighley	1	Yorkshire House-to-House Electricity Company.
Kidderminster	1	Midland House-to-House Electricity Company.
Killiney and Ballybrook ...	1	Irish House-to-House Electricity Company.
Kingston-on-Thames	1	Municipal Electric Light and Power Corporation.
Kingstown	1	Irish House-to-House Electricity Company.
Kinning Park...	1	Scottish House-to-House Electricity Company.
Leamington ...	2	Midland Electric Light and Power Company. Municipal Electric Light and Power Corporation.
Leeds	3	Electric Installation and Maintenance Company. National Electric Supply Company. Yorkshire House-to-House Electricity Company.
Leith	1	Scottish House-to-House Electricity Company.
Limerick	1	Irish House-to-House Electricity Company.
Lincoln	1	Midland House-to-House Electricity Company.

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Place.	No. of Applications.	Names of Applicants.
Little Hulton ...	1	Lancashire and Cheshire House-to-House Electricity Company.
Liverpool	1	Liverpool House-to-House Electricity Company.
Llanelly	1	Llanelly Electric Light and Power Company.
Londonderry ...	1	Irish House-to-House Electricity Company.
Longton	1	Midland House-to-House Electricity Company.
Loughborough ..	1	Brush Electrical Engineering Company.
Lowestoft	1	Midland House-to-House Electricity Company.
Luton	2	Midland House-to-House Electricity Company. Municipal Electric Light and Power Corporation.
Macclesfield ...	1	Municipal Electric Light and Power Corporation.
Maidstone	2	Municipal Electric Light and Power Corporation. South of England House-to-House Electricity Co.
Manchester.....	2	Brush Electrical Engineering Company. Laing, Wharton, and Down Construction Syndicate.
Margate	2	Municipal Electric Light and Power Corporation. South of England House-to-House Electricity Co.
Maryhill	1	Scottish House-to-House Electricity Company.
Merthyr Tydfil..	1	Western House-to-House Electricity Company.
Middlesboro' ...	1	Yorkshire House-to-House Electricity Company.
Newton Abbot.	1	Municipal Electric Light and Power Corporation.
Newport	1	Western House-to-House Electricity Company.
Newry	1	Irish House-to-House Electricity Company.
North Berwick..	1	Latimer Clark, Muirhead and Co.
Northfleet ...	1	South of England House-to-House Electricity Co.
Oldham	1	Latimer Clark, Muirhead and Co.
Paisley	1	Scottish House-to-House Electricity Company.
Partick	1	Scottish House.to-House Electricity Company.
Pemberton	1	Lancashire and Cheshire House-to-House Electricity Company.
Pembroke.....	1	Electric Lighting Company of Ireland.
Penzance.....	1	Brush Electrical Engineering Company.
Perth.....	1	Scottish House-to-House Electricity Company.
Peterborough ...	1	Midland House-to-House Electricity Company.
Pollokshields ..	1	Scottish House-to-House Electricity Company.
Portsmouth ...	1	Laing, Wharton, and Down Construction Syndicate.
Prescot	1	Lancashire and Cheshire House-to-House Electricity Company.
Preston.....	1	Electric Installation and Maintenance Company.
Ramsgate	2	Municipal Electric Light and Power Corporation. South of England House-to-House Electricity Co.
Rathmines and Rathgas	1	Irish House-to-House Electricity Company.
Rawtenstall	1	Lancashire and Cheshire House-to-House Electricity Company.
*Reading.....	2	Laing, Wharton, and Down Construction Syndicate. South of England House-to-House Electricity Co.
Richmond (Surrey)	2	Latimer Clark, Muirhead and Co. South of England House-to-House Electricity Co.
Rochdale.....	2	Lancashire and Cheshire House-to-House Electricity Company. Municipal Electric Light and Power Corporation.
Rochester	1	Chatham, Rochester, and District Electric Light Co.
Rotherham	1	Yorkshire House-to-House Electricity Company.
Ryde (I. of W.).	3	Latimer Clark, Muirhead and Co. Municipal Electric Light and Power Corporation. South of England House-to-House Electricity Co.
Saddleworth ...	1	Yorkshire House-to-House Electricity Company.
Sale	1	Manchester House-to-House Electricity Company.
Salisbury	1	Latimer Clark, Muirhead and Co.
Scarborough ...	1	Yorkshire House-to-House Electricity Company.
Sheffield	3	Electric Installation and Maintenance Company. National Electric Supply Company. Sheffield Telephone Exchange and Electric Light Co.
Shirley and Freemantle...	1	South of England House-to-House Electricity Co.
Shrewsbury.....	1	Midland House-to-House Electricity Company.
Smethwick	1	Midland House-to-House Electricity Company.
Southampton ...	3	National Electric Supply Company. Southampton Electric Light and Power Company. South of England House-to-House Electricity Co.
Southport	4	Messrs. J. D. F. Andrews and Co. Electric Installation and Maintenance Company. Lancashire and Cheshire House-to-House Electricity Company. Messrs. Sharp and Kent.
South Shields...	2	Laing, Wharton, and Down Construction Syndicate. Northern House-to-House Electricity Company.
South Stoneham	1	South of England House-to-House Electricity Co.
Southwick	1	Sunderland and District Electricity Company.
Stalybridge.....	2	Lancashire and Cheshire House-to-House Electricity Company. Municipal Electric Light and Power Corporation.
St. Helens	1	Lancashire and Cheshire House-to-House Electricity Company.
St. Mary Church (Devon)	1	Municipal Electric Light and Power Corporation.
Stockport	1	Manchester House-to-House Electricity Company.
Stoke-on-Trent	1	Midland House-to-House Electricity Company.
Stroud.....	1	Western House-to-House Electricity Company.
Sunderland.....	2	Newcastle and District Electric Lighting Company. Sunderland and District Electricity Company.
Surbiton	1	Municipal Electric Light and Power Corporation.
Swindon (New Town)	1	Latimer Clark, Muirhead and Co.
Swindon (Old Town)	1	Latimer Clark, Muirhead and Co.
Teddington.....	1	Municipal Electric Light and Power Corporation.
Tipton.....	1	Midland House-to-House Electricity Company.
*Torquay	3	Devon and Cornwall Electricity Supply Company. Devonshire Electric Light and Power Supply Co. Municipal Electric Light and Power Corporation.
*Tunbridge Wells	3	Electric Installation and Maintenance Company. Provincial Electric Light and Power Supply Co. South of England House-to-House Electricity Co.
Tynemouth.....	2	Northern House-to-House Electricity Company. Laing, Wharton, and Down Construction Syndicate.
Ventnor	1	Municipal Electric Light and Power Corporation.
Wakefield	1	Yorkshire House-to-House Electricity Company.
Warrington.....	1	Lancashire & Cheshire House-to-House Electricity Co.
Waterford	1	Laing, Wharton, and Down Construction Syndicate.
West Bromwich	1	Midland House-to-House Electricity Company.
West Cowes ...	1	Municipal Electric Light and Power Corporation.
West Hartlepool	2	Municipal Electric Light and Power Corporation. Northern House-to-House Electricity Company.
Weston-super-Mare	1	Brush Electrical Engineering Company.
Weybridge	1	Laing, Wharton, and Down Construction Syndicate.
Weymouth	2	Brush Electrical Engineering Company. Devon and Cornwall Electricity Supply Company.
Whitby	1	Yorkshire House-to-House Electricity Company.
Winchester.....	2	South of England House-to-House Electricity Co. Laing, Wharton, and Down Construction Syndicate.
Withington.....	1	Manchester House-to-House Electricity Company.
Worthing	1	Laing, Wharton, and Down Construction Syndicate.

The following list shows the number of notices which have been served by each Company individually :—

Name of Company.	No. of Notices Given.
Andrews and Co., Messrs. ..	1
Barry and Cardiff Electric Light and Power Supply Company	1
Birmingham Electric Supply Company	1
Birmingham House-to-House Electricity Company	3
Bristol Electricity Supply Company	1
Brush Electrical Engineering Company	10
Canterbury Electricity Supply Company	1
Chatham, Rochester, and District Electric Light Company	1
Chelsea Electricity Supply Company	1
Devon and Cornwall Electricity Supply Company	5
Devonshire Electric Light and Power Supply Company	2
Eastbourne Electric Light Company	1
Electric Installation and Maintenance Company	7
Electric Light and Power Supply Company	1
Electric Lighting Company of Ireland	1
Exeter Electric Lighting Company	1
Hertford Electric Light Company	1
House-to-House Electric Light Supply Company	14
Irish House-to-House Electricity Company	11
Kensington and Knightsbridge Electric Lighting Company	4
Laing, Wharton and Down Construction Syndicate	10
Lancashire and Cheshire House-to-House Electricity Company	14
Latimer Clark, Muirhead and Co.	17
Liverpool House-to-House Electricity Company	1
Llanelly Electric Light and Power Company	1
London Electric Supply Corporation	8
Manchester House-to-House Electricity Company	6
Metropolitan Electric Supply Company	5
Midland House-to-House Electricity Company	14
Municipal Electric Light and Power Corporation	31
National Electric Supply Company	6
New Cadogan and Belgrave Electric Supply Company	1
Newcastle and District Electric Lighting Company	1
Northern Counties Electric Light and Power Supply Company	1
Northern House-to-House Electricity Company	3
Paddington and Bayswater Electric Light and Power Company	1
Provincial Electric Light and Power Supply Company	1
Scottish Electric Supply Company	1
Scottish House-to-House Electricity Company	16
Sharp and Kent, Messrs.	1
Sheffield Telephone Exchange and Electric Light Company	1
Southampton Electric Light and Power Company	1
South of England House-to-House Electricity Company	16
St. James and Pall Mall Electric Light Company	1
Stamford Hill, Tottenham, and Edmonton Electric Light and Power Supply Company	1
Sunderland and District Electricity Supply Company	2
Western House-to-House Electricity Company	6
Westminster Electric Supply Corporation	5
Woolwich District Electric Light Company	1
Yorkshire House-to-House Electricity Company	14
Total number of Applications	263

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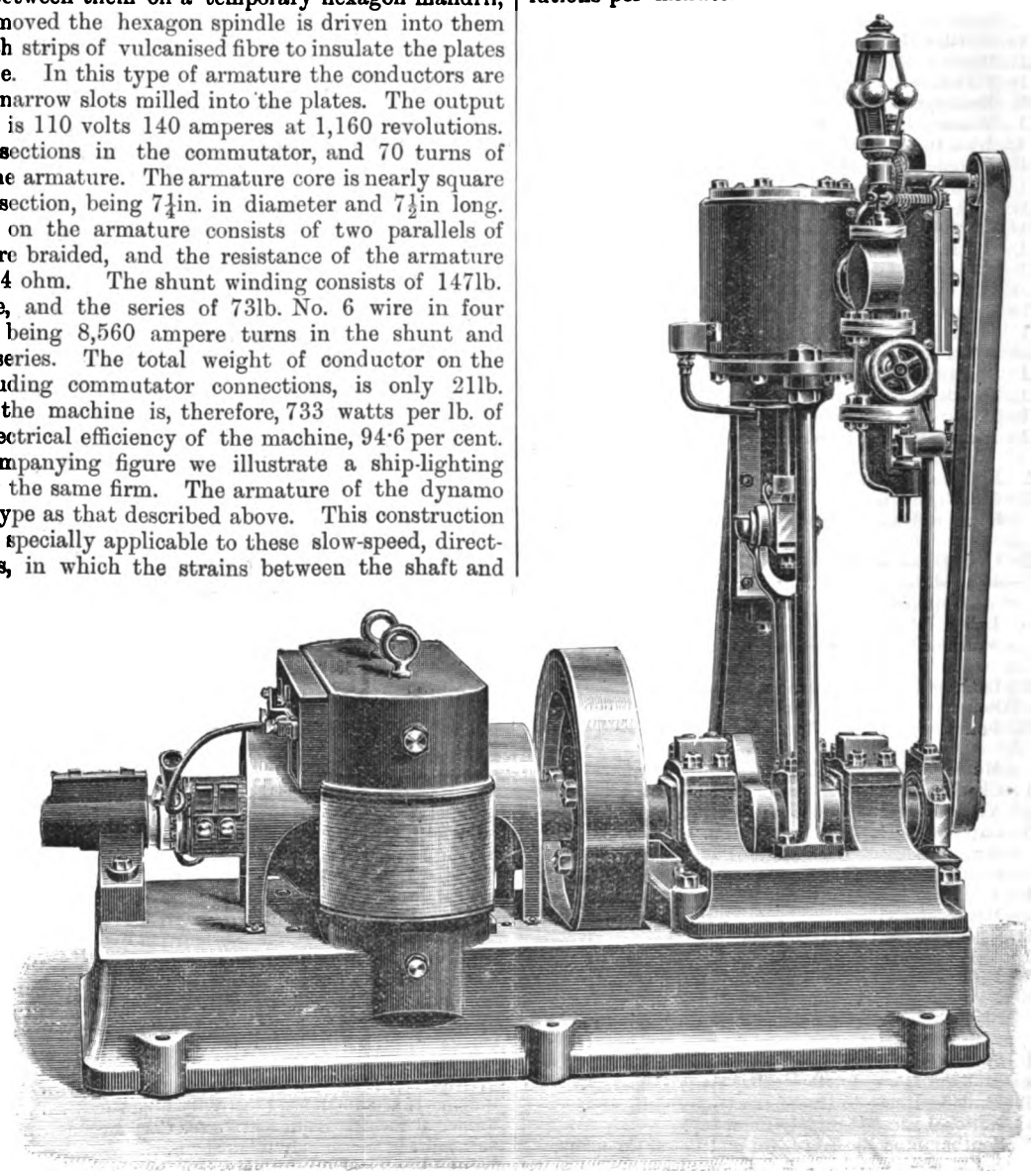
THE EDINBURGH EXHIBITION.—V.

MESSRS. LAURENCE, SCOTT AND CO.'S EXHIBIT.

Messrs. Laurence, Scott and Co., of Norwich, show on the stand of their agents for Scotland, Messrs. Norman and Son, of Glasgow, among other things one of their "D" dynamos, driven by a long stroke engine, by Messrs. Ransomes, Sims and Jefferies, of Ipswich. The magnets of this machine are of the "Kapp" type, made of specially soft cast-iron. The drum armature is built up on the system which Messrs. Laurence, Scott and Co. have used for several years. The plates are stamped with hexagon holes placed together, with the insulating material between them on a temporary hexagon mandril, which being removed the hexagon spindle is driven into them very tightly with strips of vulcanised fibre to insulate the plates from the spindle. In this type of armature the conductors are wound in deep narrow slots milled into the plates. The output of the machine is 110 volts 140 amperes at 1,160 revolutions. There are 70 sections in the commutator, and 70 turns of conductor on the armature. The armature core is nearly square in longitudinal section, being 7¼in. in diameter and 7½in long. The conductor on the armature consists of two parallels of ·12in. round wire braided, and the resistance of the armature when hot is ·024 ohm. The shunt winding consists of 147lb. of No. 17 wire, and the series of 73lb. No. 6 wire in four parallels, there being 8,560 ampere turns in the shunt and 5,520 in the series. The total weight of conductor on the armature, including commutator connections, is only 21lb. The output of the machine is, therefore, 733 watts per lb. of copper. The electrical efficiency of the machine, 94·6 per cent.

In the accompanying figure we illustrate a ship-lighting plant shown by the same firm. The armature of the dynamo is of the same type as that described above. This construction of armature is specially applicable to these slow-speed, direct-driven machines, in which the strains between the shaft and the armature conductor are so much greater and more trying than in an ordinary belt-driven machine. The output of the dynamo is 60 volts 75 amperes, at the slow speed of 260 revolutions per minute. Messrs. Laurence, Scott and Co. always test these ship-lighters before leaving their works for six hours at "load and a half," and for twelve hours at full load. The engine itself is by Messrs. Sabberton Bros., of Norwich. The crank is of forged steel, slotted and fitted with balance weights; the connecting-rod, also of forged steel, is six cranks long. All the bearings and wearing surfaces are very large, and fitted with suitable lubricating arrangements, to enable it to run continuously at a high speed. The cylinders are 6in. diameter, and 6in. stroke, and the engine will run well up to 1,100 revolutions per minute.



4½-kilowatt Ship Lighting Plant.

SOME NEW VACUUM JOINTS AND TAPS.*

BY W. A. SHENSTONE.

In making joints in ordinary vacuum apparatus it is usual to provide a cup, and to grind a glass stopper to fit the tube to which it is attached. The cup is filled with glycerine or mercury which acts as a seal to the joint thus formed. The objection to this is, that if the position of the stopper is shifted, the mercury enters the apparatus, and in many cases is very objectionable, and in some cases it would altogether vitiate the results. The author had recently been engaged in the production of pure oxygen, and had occasion to make and break joints without admitting anything to the apparatus. He devised a form of joint in which the plug was upside down, and on suggesting this to Mr. Cundall who was working with him, he found that he had hit on the same idea, and had begun to construct one. He exhibited a specimen of such a joint (Fig. 1).

He had also felt the want of a joint which would withstand pressure in either direction. Any pressure on the interior of such a joint as he had described would cause it to leak if not to blow out, as the seal was in one direction only, consequently it could not be used with manometers. He had thought of a tap which could be worked from within or without, and had considered electro-magnetic methods for working it. He had

* Abstract of a Paper read before the British Association in Section A, Leeds, September, 1890.

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eventually arranged a double seal, and exhibited a joint made in this way (Fig. 2). It was provided with a means of making or breaking the joint, which was a ready way of introducing the mercury to the inner seal. A flat was filed on the taper plug (Fig. 3) and a groove was cut on the inner side of the tube which had been ground to fit it. When these two cuts were turned to be in line, a passage was formed by them, and when turned round this was shut off. Another pattern was exhibited, in which the mercury was introduced to the inner seal by means of a branch tube, which could be sealed off after use.

In ordinary glass plug taps a difficulty often arose owing to the air, which was contained at the bottom of the hole into which the glass plug was ground. This could not be got over by introducing anything into the hole before the plug was put in place. If the well were filled with mercury, when the plug was put in, it displaced the mercury, and some of it would remain between the ground surfaces of the plug and the hole, interfering with the working. The improvement which he had effected was merely to drill a hole from the bottom of the plug through the axis to the cross hole, thus placing the cavity below the plug in communication with the passage through the

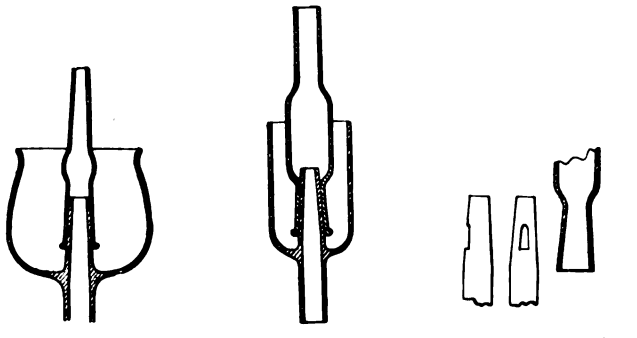

FIG. 1. FIG. 2. FIG. 3.

plug. When air or gas passed through the tap it filled the cavity as well as the tubes to which the tap was connected, and when these were exhausted, the cavity below the plug was also exhausted.

DISCUSSION.

Mr. SWINBURNE said that a difficulty arose in the use of ground-glass taps in finding a good lubricant. For most purposes, and for all vacuum purposes, one could not use hydrocarbons. He had found silicate of soda to be the best thing to use, but would ask Mr. Shenstone if he could suggest anything better.

Mr. SHENSTONE in reply said that he was aware of the difficulty and had used silicate of soda, but he had found that it acted on the glass; and after a vacuum apparatus had been set up for a few weeks spots of a white appearance were to be found on the surface of the plug, and these tended to increase, and eventually the two surfaces of the glass would unite together. He had found that pentoxide of phosphorous or syrupy phosphoric acid was a good lubricant, and he had not discovered any bad results from its presence.

REPORT OF THE COMMITTEE ON ELECTRICAL STANDARDS.*

The work of testing resistance coils at the Cavendish Laboratory has been continued. A table of values found for the coils is appended:—

LEGAL OHMS.

No. of Coils.				Resistance in legal ohms.	Temperature.
Nalder	1577	C.L.C.	189	·99981	16·9
Nalder	1578	C.L.C.	190	1·00089	16·9
Nalder	1579	C.L.C.	191	1·00041	16·9
Edison Swan	16	C.L.C.	192	·99846	13·9
Elliott	229	C.L.C.	193	1·00028	16·9
Elliott	230	C.L.C.	194	1·00021	16·9
Simmons		C.L.C.	195	·99992	16·8
Nalder	1626	C.L.C.	196	1·00045	15·3
Nalder	1627	C.L.C.	197	1·00056	15·3
Nalder	1628	C.L.C.	198	1·00058	14·8
Nalder	1580	C.L.C.	199	1·00072	15·3

* Read before the British Association in Section A, Leeds, September, 1890.

It would be of considerable advantage in the testing if all the coils were made of a uniform size. The original standards of the Association measure 6¾in. from the bottom of the case to the underside of the horizontal portion of the copper connecting rods, while the vertical portion of these rods is 8in. in length. These dimensions should be adopted in all coils sent to be tested; if this be done, the baths, &c., made to hold the standards hold the coils equally well, and the additional convenience in testing is very great great.

The original standards of the Association have again been several times compared among themselves. The results of the comparisons appear to show that while the coils A, B, C, D, E, and Flat have remained constant relative to each other, the three platinum silver coils F G and H have changed. The change in F was referred to at the end of the Report in 1888, and is now very large. The coil has increased in resistance by about ·0006 B.A. unit; G, on the other hand, has fallen by about ·0002 B.A. unit, and H by about ·0001 unit. The evidence for these various statements is given in an appendix to the Report by the secretary. It is, perhaps, worth remark that in each case the change either took place during the time that the coil was immersed in ice, or was found to have happened when the coil was next measured after its removal from the ice. The legal ohm coils have not varied relative to Flat.

The investigations into the resistance of copper have been continued by Mr. Fitzpatrick. The committee desire again to thank the gentlemen who have rendered him assistance in various ways.

Mr. Fitzpatrick has examined various specimens of copper supplied him as wire. He has also examined copper prepared for him as pure by Messrs. Sutton, as well as some which he prepared himself electrolytically from carefully purified copper sulphate. These last two specimens lead to practically the same value as that obtained by Matthiessen for the specific resistance of copper, viz., 1767×10^{-9} B.A. units at 18deg.; the specific gravity of these specimens is about 8·90. Two wires supplied to him have, however, a distinctly lower resistance: the value for one being 1731×10^{-9}, and for the other 1724×10^{-9}; a difference in the one case of 2 and in the other of 2·4 per cent. The specific gravity of the first of these wires is 8·940, and of the other 8·946, and Mr. Fitzpatrick assigns the increased conductivity to increased density rather than to greater purity.

Matthiessen gives his results for the resistance of copper at 0deg. The observations were, however, made mostly at a temperature of 18deg. or 20deg., and reduced to 0deg. by the use of a temperature coefficient. So that the value at 18deg. found from that at 0deg. by the same coefficient will probably represent the result of Matthiessen's work more accurately than the one he gives himself. Various other points of importance are discussed in Mr. Fitzpatrick's appendix. He hopes to be able to give the results for some copper prepared by chemical means by Mr. Skinner and himself. He has also made a number of measurements on silver, but these are not yet complete.

Dr. Muirhead and the Secretary have both been working independently at the construction and measurement of a standard air condenser. Two such condensers have been made for the Committee by the Cambridge Scientific Instrument Company, on a plan suggested by Dr. Muirhead, and mentioned in the last Report. The capacity of each of these is about ·02 microfarad. Some slight alterations are required to one of these, the other is completely satisfactory. Its capacity has been repeatedly found, and remains constant to at least within 1 in 2,000, which is about the limit of accuracy attained. Its insulation resistance is good, the loss by leakage being about 1 in 1,000 of the total charge per one minute. It has been found possible to compare readily with this standard various mica condensers having capacities of 1, ·5, ·1, and ·05 microfarad. The accuracy of these determinations is about 1 in 2,000. A full account of the construction of the condensers, and of the method of making the various tests, is given in an appendix by the Secretary, while Dr. Muirhead has contributed some notes on his own condensers and tests.

Another appendix contains an account of a very careful and interesting comparison between the standard mercury ther-

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mometers of the Association and a platinum resistance thermometer constructed by Mr. E. H. Griffiths. The resistance thermometer was graduated by means of Regnault's numbers for the vapour pressure of water at various temperatures between 0° and 100°. The curve of corrections obtained in this way is exactly parallel to that given by the Kew comparisons; there is throughout the range a constant difference of 0°·02 between them. This amount is within the limits of error on the mercury thermometer.

The question of the best value to adopt for the dimensions of a mercury column having a resistance of one ohm has been raised by some members of the committee during the year. There is no doubt that the column of 106 centimetres adopted by the Paris Conference in 1884 is too short. After a discussion of the results of the most recent observations, the following resolutions were adopted by the committee :—

(1) The committee recommend for adoption as a standard of resistance sufficiently near to the absolute ohm for practical purposes the resistance of a column of mercury 106·3 cm. in length one square mm. in section at a temperature of 0°C.

(2) That for the purpose of issuing practical standards of resistance the number ·9866 be adopted as the ratio of the B.A. unit to the ohm.

Thus the new unit may be obtained from the B.A. unit by increasing it in the ratio ·9866 to unity, or, to put it differently, the specific resistance of mercury in B.A. units is taken as $\cdot 9535 \times 10^{-4}$ and the length of a column of mercury which has a resistance of 1 B.A. unit as 104·97.

The specific resistance of mercury in ohms in thus :—

$$\cdot 9407 \times 10^{-4}.$$

In conclusion, the committee wish to ask for reappointment to enable them to continue the work of constructing and issuing standard instruments. Of the grant of £50 made at Newcastle only £12. 17s. has been drawn. In order to check any further change in the values of the B.A. units, and to render it less necessary to employ the original standards in all the comparisons which are made, it is desirable that the committee should possess three or four copies of the B.A. unit; while, to enable comparisons to be made between the new air condensers and condensers of capacity comparable with a microfarad, a resistance box going up to several hundred thousand ohms is required.

The committee are of opinion that they should be in a position to purchase these resistances; they, therefore, recommend that they be reappointed with a grant of £100, that Prof. Carey Foster be the chairman, and Mr. R. T. Glazebrook secretary.

THE COUPLING AND CONTROL OF DYNAMOS IN CENTRAL STATIONS.—III.*

(*Concluded from page 470.*)

Alternating Currents.—The usual arrangement is to have a number of independent dynamos and a number of independent circuits leading to separate districts. One or more of the circuits is connected to each machine. As the number of lamps on each circuit diminishes, more circuits are put on to each machine, and the number of machines in use is reduced. The machines thus do not run in parallel at all. One argument against parallel running, which is especially used in the States, is that faults are constantly occurring on the high-tension circuits. If all the circuits are connected together, a fault on any positive lead in conjunction with a fault on any negative lead causes a short circuit, which may have more or less disastrous effects according to the arrangements of the circuits and dynamos, while, on the separate circuit system, faults on positive and negative leads of the same dynamo are needed before there is any accident. Against this it is to be urged that an armature of any machine going wrong puts a district out, and high-tension alternating armatures do go wrong very easily. It would, therefore, seem better to secure the advantages of both these systems. It is not at all necessary that the circuits should be metallically connected; one leading feature of alternating currents is the ease with which they can be managed. If the dynamos themselves give high pressures, as is usually the case, one or more external circuits may be connected to each dynamo, but the whole of the dynamos may be coupled to work in parallel without any metallic connection whatever. This arrangement is shown in Fig. 1. Three dynamos, A, B, C, are connected directly to circuits. A has two external circuits, B one, and C three. An earth on the positive of one of the circuits of, say 1, in conjunction with one on the negative of a circuit on, say 4, causes no stoppage, as there is no metalli connection between the circuits. If a leak came on the positive of 4 and negative of 6, there would be a stoppage; but by transferring 4 or 6 to another machine, a start can be made at once. The dynamos are also connected to a transformer D. This is wound with as many circuits as there are dynamos in parallel. Three only are shown. The transformer need not be large; its utmost capacity need only be enough to enable it to give the output of one dynamo for a few minutes. Ordinarily this transformer has no load except what little may be necessary to keep the dynamos in step. If one dynamo, say C, breaks down, the transformer takes power from A and B, and supplies to the circuits belonging to C. If C had an armature short circuit, or a break in its exciting current, its fuse will have blown, and it will be disconnected. The transformer need only be able to supply power till an attendant has put the circuits 4, 5, and 6 on another dynamo, so the current density allowed may be very high. This high-current density occurs only in the coil acting as secondary. As all the other coils act as primaries in parallel, their current densities are low.

If the dynamos are wound for low tension, and transformers are used to give the high pressure for the mains, there is less difficulty. All the dynamos may feed into one large transformer, or into a bank of several, the primaries, or low-pressure circuits, all being connected together. It is strange that transforming up is not used more. At first it was to have been used at Deptford, but the scheme was altered. The arguments against it are that the transformers waste power and cost money. As to loss of power

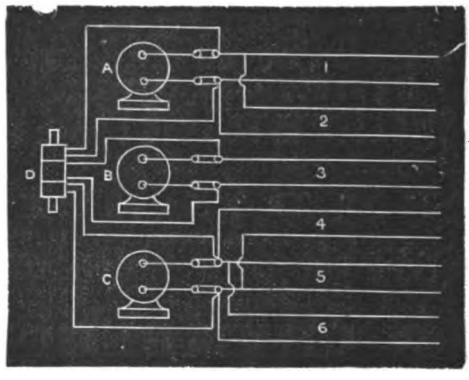

FIG. 1.

the efficiency of a large station transformer can be raised above 99 per cent. including the loss in the iron, by use of the open circuit, and very nearly as high with a closed circuit, if the arrangement is such that the transformers can be cut in or out so that those in use are always at full load. The loss in efficiency is also counterbalanced by gain in the dynamo. An armature wound for 2,000 volts has small wire and a great deal of insulation. The insulation is not only costly, sometimes running up to about £30 for mica alone, but it takes up room that could be much better occupied with copper conductor. The whole dynamo can thus be made more efficient by winding it for low pressure, and its increased efficiency probably compensates, or almost compensates, for the loss of power in the transformers. In many cases it is also possible to arrange the whole station on the low-pressure side of the transformers. The switches, couplings, fuses, and instruments then demand neither troublesome insulation nor careful handling, and this alone is an enormous advantage. The cost of large transformers is also very trifling. They can be made for less than sixpence per 8 candle-power lamp, which is nothing in comparison with the saving in using them.

In transforming up, if there are a number of external circuits, as in Fig. 1, to avoid chances of breakdown through faults, a large transformer, or a bank of them, may be arranged with several high-pressure circuits, as shown in Fig. 2. In this case the switches and gear are not all on the low-pressure side, but the arrangement has the advantage of allowing the transformers to be cut in and out, and it also admits of regulation of the pressures on the high-tension circuit by cutting turns in or out. Circuits 1 and 2 are shown regulated that way. The transformers E F G may, of course, be of any form, and are shown merely diagrammatically. Circuit 5 is shown as regulated by a step-up transformer. This arrangement has been patented several times. Mr. Kapp has patented a step-up transformer for insertion in a feeder. He did not propose to use it in conjunction with a transforming-up arrangement, and altered

* Abstract of an article by James Swinburne in *Industries*.

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the numbers of turns in it secondary instead of its primary, which is not quite so convenient. The dynamos in Fig. 2 may or may not be coupled to run in parellel. The high-tension circuits can also be arranged on the three-wire system without any complications.

Another arrangement is shown in Fig. 3. The dynamos are all connected in parallel, and there is one transformer for each circuit. The regulating gear and switches are then all on the low-pressure side, but each circuit or feeder is regulated independently. This arrangement demands a larger number of transformers, and is, therefore, slightly more expensive, and all the transformers are always in circuit, which is not a good arrangement. Of course, this arrangement can work without the dynamos running in parallel. Step-up transformers can also be used to regulate, instead of having spare turns on the large transformers. This avoids high-tension switches to some extent.

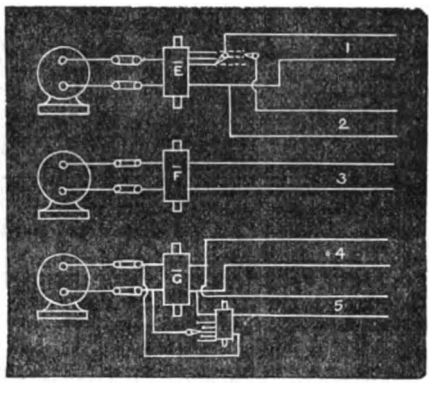

Fig. 2.

Turning now to the question of government, if each alternator is run from a single engine, and the machines are not run in parellel, the engines may have speed or electrical pressure governors. There is nothing to add here to what has been said in connection with direct currents. If, however, an electric governor is used, which acts on the exciting current of the exciter, there is a strong tendency to hunting, as, when the exciter field is altered, there is often a considerable time before the main dynamo feels it. I have used governors which would act when employed to regulate the main field, but hunted intolerably when set to control the field of the exciter. It is usual to supply a separate exciter for each dynamo. This seems to be a thoughtless survival from the early days of alternating currents. There is no reason why two engines and dynamo, with a spare at hand, should not supply exciting power for all the alternators in a station. Such an arrangement would be very much safer and considerably cheaper.

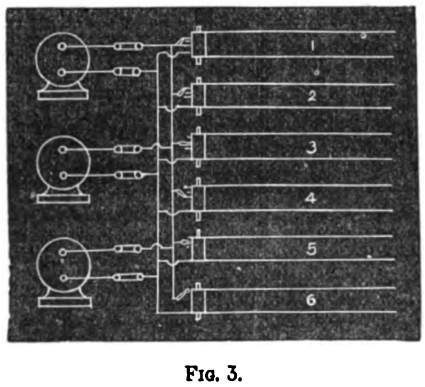

Fig. 3.

The question of the coupling of alternators in parallel is commonly dealt with in a somewhat random and general way. Under the circumstances, I also may be allowed to treat the subject somewhat dogmatically, and to give my own theory of the matter as if it were acknowledged to be correct.

The parallel running of ordinary alternators, or their availability as motors with varying loads, depends not on whether the armature has iron or not, or whether the pressure falls as the current increases when run on resistances, but on the armature reactions and the resistances of the armature. If the field of the machine is also altered, the problem is apparently more complicated, but is really simpler. As self-exciting dynamos, and probably motors, will without doubt soon come into much more general use, and as they go far towards solving the problem, I will deal with various modes of exciting as if they were as common as in the case of direct currents. As the principles underlying working dynamos in parallel and synchronising motors on parallel supply circuits are the same, they may be explained together. The case of an alternate-current supply circuit may be taken. A machine without friction may be imagined, and when its field magnets are separately excited so as to give an electromotive force exactly equal to that of the mains when it is connected, so as to be co-phasedly synchronised, it runs as a motor, taking no current. At each instant the electromotive force of the machine is exactly equal to the electromotive force of the mains, so no current passes. If power is applied to the machine, it becomes a generator; if load is put on it becomes a motor. On putting on some load the machine begins to lag. As soon as the machine lags, a current passes through the armature. If the electromotive force of the machine were still the same as that of the mains it is clear that it would develop no power as a motor, because at some parts of the period it would be supplying power to the mains, and at other parts of the period the mains would be supplying power to the armature. The electromotive force of the machine does not, however, remain equal to the main electromotive force, merely differing from it in phase, but it is decreased by the reaction of the armature current on the field magnets. This weakening of the field by the armature reaction allows the mains to do more work on the machine than the machine does on the mains, so that the machine acts as a motor, and power can be taken from it. If the load is altered, the machine will increase or decrease its lag, so that its effective field is reduced to just the right value to allow the machine to absorb electrically the power taken from it mechanically. As lag is necessary in order to weaken the effective field, so the current in the armature is no longer co-phasedly synchronised with the electromotive force of the mains. The result of this is that the current is not at the maximum value at the same instants as the electromotive force is; so that the power taken by the motor is less than the product of the effective electromotive force of the mains and the effective current of the machine. The electromotive force and current may be so much out of step that the power of the motor is small though the armature current is large. The availability of the machine as a motor thus depends on the resistance of the armature and on its reaction on the field.

For instance, if the machine has very little armature resistance, a very small reduction of its electromotive force will allow a large armature current to pass. If, on the other hand, the armature resistance is high, the armature must have a large reaction on the field so as to reduce the effective electromotive force of the machine considerably when it lags. If, at the same time the load is put on, the field of the motor is artificially weakened by reducing the excitation, the electromotive force of the machine may be reduced enough to allow current from the mains to act in step with the main electromotive force. For instance, if the supply circuit is of 100 volts, and if an ordinary separately excited 100-volt machine is connected and excited so as to give 100 volts with the same vibration frequency, or periods per second, as prevails in the mains, and if this machine is loaded as a motor with 100 horse-power, it will lag until the field is weakened enough to let sufficient current pass to give the power. This current will be more than 746 amperes, though the machine, if fairly efficient, does not need much more than 746 watts to give out 1 horse-power. But if the machine as a dynamo can give 746 amperes with the loss of five volts in the armature, due to the resistance, and if the machine is excited so as to give 95 volts on open circuit at the normal speed, and is then thrown into the circuit at an instant when it is in step, and a load of 95 horse-power taken out, it will remain in step, for the electromotive force of the machine is always just enough below the main electromotive force to allow the right current to pass. The effective current is then 746 amperes. The main circuit thus supplies 100 volts and 746 amperes, or 100 horse-power. Five horse-power is lost in overcoming the resistance of the armature, and 95 is available at the pulley. The losses by friction and Foucault currents are here neglected for the sake of simplicity. In practice a little less than 95 horse-power would be obtained for external use. If the field has not been weakened by reducing the excitation, the effective current—that is to say, the current as measured by an electro-dynamometer—would be considerably more than 746 amperes, let us say 1,500 amperes. The power given to the motor would, of course, however, be much less than 150,000 watts, as the current would be out of step with the electromotive force. The armature loss in the case already taken was 5 per cent., or 5 horse-power with 746 amperes; with 1,500 it would be 20 horse-power. The mains would thus supply 115 horse-power, of which 20 would be spent in the armature of the machine. In order to stand an armature loss of 20 horse-power without excessive heating, the machine, must be made much larger, and the electrical efficiency of the armature is much lower, 82·6 instead of 95. Thus, by lessening the ampere turns on the field of the motor as the load increases it is possible to make it work as efficiently and give as large an output as a motor as when employed as a generator.

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If the machine is to be worked as a generator in parallel with the main circuit, the same reasoning holds good. If the machine is excited so as to give 100 volts at no load and is thrown into circuit at an instant when it is in step, if the engine supplies just enough power to overcome friction there will be no armature current, as the electromotive force of the machine will, at every instant of the period, be exactly equal and opposite to that of the mains. If the engine supplies just a little too much power the machine will begin to lead, and an armature current will pass, which will strengthen the fields by reaction, and the machine will at some instant act as a generator, because its electromotive force is now a little higher, as the armature current has strengthened its field. Similarly, if the steam of the engine were completely shut off, the machine would lag until it worked as a motor. If now the steam is turned on until the dynamo supplies 100 horse-power to the mains, the machine will increase its lead until the armature current strengthens the field enough to give the output. The armature current will not be in step with the electromotive force, so the current will be more than 746 amperes. If it is 1,500 amperes, which is not unlikely, the armature loss will be 20 horse-power.

It may be well to remark that the theory here given is not rigidly correct. In various theoretical investigations of armature reactions I have divided the action of the armature current into two portions capable of separate treatment, which I have called the "back induction" and "cross induction" respectively. These terms have now come into general use, so need not be defined. In the theory as explained above, I have only taken the back induction into account, and have, for the sake of simplicity, neglected the complications arising from cross induction. It is thus possible, by altering the field excitation of such dynamos, to make them work well as generators or motors on supply circuits. Instead of depending on the reaction of the armature to strengthen or weaken the effective field, the field excitation may be regulated so that the current and electromotive force of the machine are always in step or very nearly so.

Take first the case of a separately excited motor. The field magnets have an additional set of coils, and these are put in series with the main armature current, which is redressed or rectified by a commutator. These coils are arranged so as to demagnetise or weaken the field as the current increases, so that it is not necessary for the machine to lag in order to take a large load.

The redressed current might be used to demagnetise the fields of the exciter, but it is more prompt and better to act on the fields of the alternating machine itself. If the dynamo is made to excite itself with special exciting coils on the main armature, as in the case of some of Prof. Elihu Thomson's machines, it is especially useful for parallel working. If a machine made in this way is used as a motor without series demagnetising circuits round the field-magnets, it begins to lag as soon as load is put on, and the armature current then reacts on the pole-pieces and lessens the effective fields. As the exciting coils now pass through the same field, this will also lessen the magnet excitation directly, and as soon as the effective field is weakened by the armature reaction the ampere turns round are also reduced because the electromotive force in the exciting circuit is lessened. A very small lag will thus weaken the field considerably, so that a large load may be put on without the lag being great enough to make the machine inefficient. A series demagnetising circuit may be used in addition. If the ampere turns of the field-magnet are not adjusted to the load with perfect accuracy the machine adjusts itself by lagging or leading very slightly. Of course, cast-iron field-magnets are apt to give trouble, as they do not always follow the change of excitation quickly enough.

Machines with fields excited chiefly by special exciting circuits on the main armatures and partly by series circuits are useful for working in parallel as generators. The series circuits are then arranged to magnetise instead of demagnetise. If power is applied to a motor instead of taken from it it becomes a generator, and the direction of its main current is reversed, both in the armature and the series coils on the fields, so that a motor with a backward series circuit becomes a generator with a forward series circuit. If one machine, when used as a generator, begins to lead because too much power is supplied to it by its engine, its field is strengthened by the series currents, and this increases the armature electromotive force enough to make it give a large output corresponding to the power supplied to it. If machines excited from special armature circuits without series circuits are run in parallel they will keep in step, because the least loading or lagging alters the field excitation.

The compound form is best, because the whole station will then supply the mains at constant pressure if all the engines are mechanically governed for constant speed of one of them—that is to say, the whole steam supply is regulated to keep the speed of all the engines constant, the engines taking the steam in proportion to their size. Instead of keeping the speed constant, an electric governor can keep the electromotive force of the whole station constant. With alternate machines, as at present commonly used, it is necessary to alter the field excitation by hand or by automatic gear. Self-exciting compound machines have advantages corresponding to compound machines in direct-current work compared with shunt or separately excited machines. The analogy between these alternate machines and compound or separate armature circuit direct-current machines must not be pushed too far. In direct-current machines the electromotive force adapts itself by slight alterations of speed, and the armature reaction depends on the position of the brushes; in alternate machines the speed is unalterable, and the armature reaction depends on lead and lag. These compound machines may need to be coupled like direct-current compound machines to avoid any tendency to reversal. At present engineers nearly always use separate exciters, one for each alternator. Most likely, in a very few years, the various ways of exciting alternators, and the properties of the various windings, will be as well understood as in the case of direct-current dynamos.

THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

(Continued from page 564.)

Generalities concerning Electro-Magnets.

Materials.—In any complete treatise on the electro-magnet it would be needful to enumerate, and to discuss in detail, the several constructive features of the apparatus. Three classes of material enter into its construction: first, the iron which constitutes the material of the magnetic circuit, including the armature as well as the cores on which the coils are wound, and the yoke that connects them; secondly, the copper which is employed as the material which conducts the electric currents, and which is usually in the form of wire; thirdly, the insulating material employed to prevent the copper coils from coming into contact with one another, or with the iron core. There is a further subject for discussion in the bobbins, formers, or frames upon which the coils are in so many cases wound, and which may in some cases be made in metal, but often are not. The engineering of the electro-magnet might well furnish matter for a special chapter.

Typical Forms.

It is difficult to devise a satisfactory or exhaustive classification of the varied forms which the electro-magnet has assumed; but it is at least possible to enumerate some of the typical forms.

1. *Bar Electro-Magnet.*—This consists of a single straight core (whether solid, tubular, or laminated), surrounded by a coil. Fig. 3 (*The Electrician*, September 12th, p. 527), depicted Sturgeon's earliest example.

2. *Horse-shoe Electro-Magnet.*—There are two sub-types included in this name. The original electro-magnet of Sturgeon (Fig. 1) really resembled a horse-shoe in form, being constructed of a single piece of round wrought iron, about half an inch in diameter, and nearly a foot long, bent into an arch. In recent years the other sub-type has prevailed, consisting, as shown in Fig. 11, of two separate iron cores, usually cut from circular rod, fixed into a third piece of wrought iron, the yoke. Occasionally this form is modified by the use of one coil only, the second core being left uncovered. This form has received in France the name of *aimant boiteux*. Its merits will be considered later. Sometimes a single coil is wound upon the yoke, the two limbs being uncovered.

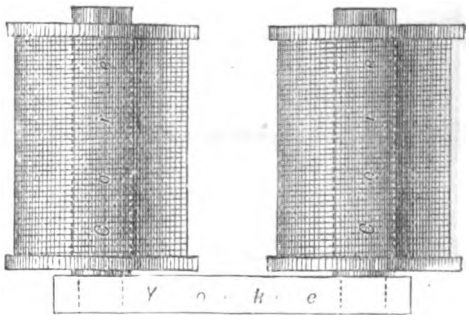

FIG. 11.—Typical Two-Pole Electro-Magnet.

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

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3. *Iron-clad Electro-Magnet.*—This form, which has many times been re-invented, differs from the simple bar magnet in having an iron shell or casing external to the coils, and attached to the core at one end. Such a magnet presents, as depicted in Fig. 12, a central pole at one end surrounded by an outer annual pole of the opposite polarity. The appropriate armature for electro-magnets of this type is a circular disc or lid of iron.

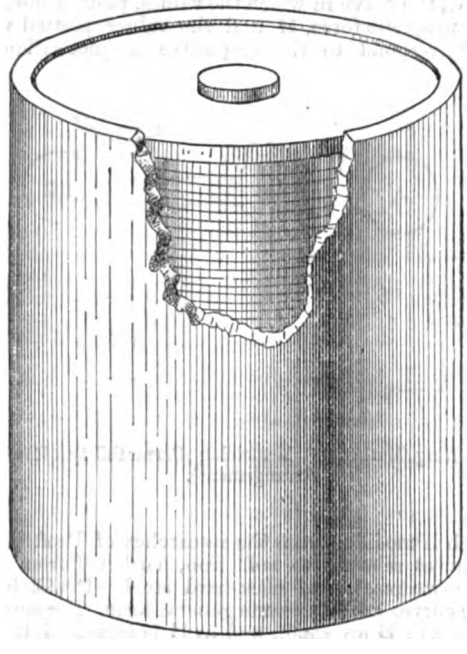

FIG. 12.—Iron-clad Electro-Magnet.

4. *Coil-and-Plunger.*—A detached iron core is attracted into a hollow coil, or solenoid, of copper wire, when a current of electricity flows round the latter. This is a special form, and will receive extended consideration.

5. *Special Forms.*—Besides the leading forms enumerated above, there are a number of special types, multipolar, spiral, and others designed for particular purposes. There is also a group of forms intermediate between the ordinary electro-magnet and the coil-and-plunger form.

Polarity.

It is a familiar fact that the polarity of an electro-magnet depends upon the sense in which the current is flowing around it. Various rules for remembering the relation of the electric flow and the magnetic force have been given. One of them that is useful is that when one is looking at the north pole of an electro-magnet, the

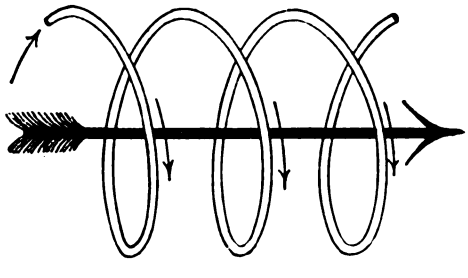

FIG. 13.—Diagram illustrating relation of Magnetising Circuit and resulting Magnetic Force.

current will be flowing around that pole in the sense opposite to that in which the hands of a clock are seen to revolve. Another useful rule, suggested by Maxwell, is illustrated by Fig. 13, namely, that the sense of the circulation of the current (whether right or left-handed), and the positive direction of the resulting magnetic force are related together in the same way as the rotation and the travel of a right-handed screw are associated together. Right-handed rotation of the screw is associated with forward travel. Right-handed circulation of a current is associated with a magnetic force tending to produce north polarity at the forward end of the core.

Uses in General.

Regarded as a piece of mechanism, an electro-magnet may be regarded as an apparatus for producing a mechanical action at a place distant from the operator who controls it; the means of communication from the operator to the distant point where the electro-magnet is being the electric wire. The uses of electro-magnets may, however, be divided into two main divisions. For certain purposes an electro-magnet is required merely for obtaining temporary adhesion or lifting power. It attaches itself to an armature, and cannot be detached so long as the exciting current is maintained, except by the application of a superior opposing pull. The force which an electro-magnet thus exerts upon an armature of iron, with which it is in direct contact, is always considerably greater than the force with which it can act on an armature at some distance away, and the two cases must be carefully distinguished. *Traction* of an armature in contact, and *attraction* of an armature at a distance, are two different functions. So different, indeed, that it is no exaggeration to say that an electro-magnet designed for the one purpose is unfitted for the other. The question of designing electro-magnets for either of these purposes will occupy a large part of these lectures. The action which an electro-magnet exercises on an armature in its neighbourhood may be of several kinds. If the armature is of soft iron, placed nearly parallel to the polar surfaces, the action is one simply of attraction, irrespective of the polarity of the magnet. If the armature lies oblique to the line of the poles there will be a tendency to turn it round, as well as to attract it; but, again, if the armature is of soft iron the action will be independent of the polarity of the magnet, that is to say, independent of the direction of the exciting current. If, however, the armature be itself a magnet of steel permanently magnetised, then the direction in which it tends to turn, and the amount, or even the sign of the force with which it is attracted, will depend on the polarity of the electro-magnet, that is to say, will depend on the direction in which the exciting current circulates. Hence there arises a difference between the operation of a *non-polarised* and that of a *polarised* apparatus, the latter term being applied to those form in which there is employed a portion—say an armature—to which an initial fixed magnetisation has been imparted. Non-polarised apparatus is in all cases independent of the direction of the current. Another class of uses served by electro-magnets is the production of rapid vibrations. These are employed in the mechanism of electric trembling bells, in the automatic breaks of induction coils, in electrically-driven tuning-forks such as are employed for chronographic purposes, and in the instruments used in harmonic telegraphy. Special constructions of electro-magnet are appropriate to special purposes such as these. The adaptation of electro-magnets for the special end of responding to rapidly alternating currents is a closely kindred matter. Lastly, there are certain applications of the electro-magnet, notably in the construction of some forms of arc lamp, for which it is specially sought to obtain an equal, or approximately equal, pull over a definite range of motion. This use necessitates special designs.

The Properties of Iron.

A knowledge of the magnetic properties of iron of different kinds is absolutely fundamental to the theory and design of electro-magnets. No excuse is therefore necessary for treating this matter with some fulness. In all modern treatises of magnetism the usual terms are defined and explained. Magnetism, which was formerly treated of as though it were something distributed over the end-surfaces of magnets, is now known to be a phenomenon of internal structure; and the appropriate mode of considering it is to treat the magnetic materials, iron and the like, as being capable of acting as good conductors of the magnetic lines; in other words, as possessing great magnetic permeability. The precise notion now attached to this word is that of a numerical coefficient. Suppose a magnetic force—due, let us say, to the circulation of an electric current in a surrounding coil—were to act on a space occupied by air; there would result a certain number of magnetic lines in that space. In fact, the intensity of the magnetic force, symbolised by the letter H, is often expressed by saying that it would produce H magnetic lines per square centimetre in air. Now, owing to the superior magnetic power of iron, if the space subjected to this magnetic force were filled with iron instead of air, there would be produced a larger number of magnetic lines per square centimetre. This larger number in the iron expresses the degree of magnetisation in the iron; it is symbolised[45] by the letter B. The ratio of B to H expresses the permeability of the material. The usual symbol for permeability is the Greek letter μ. So we may say that B is equal to μ times H. For example, a certain specimen of iron, when subjected to a magnetic force capable of creating, in air, 50 magnetic lines to the square centimetre, was found to be permeated

[45] The following are the various ways of expressing the three definitions:—B, the internal magnetisation; the magnetic induction; the induction; the permeation; the number of lines per square centimetre in the material. H, the magnetising force at a point; the magnetic force at a point; the intensity of the magnetic force; the number of lines per square centimetre that there would be in air. μ, the magnetic permeability; the permeability; the specific conductivity for magnetic lines; the magnetic multiplying power of the material.

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by no fewer than 16,062 magnetic lines per square centimetre. Dividing the latter figure by the former, gives as the value of the permeability at this stage of the magnetisation 321, or the permeability of the iron is 321 times that of air. The permeability of such non-magnetic materials as silk, cotton, and other insulators, also of brass, copper, and all the non-magnetic metals is taken as 1; being practically the same as that of the air.

This mode of expressing the facts is, however, complicated by the fact of the tendency in all kinds of iron to magnetic saturation. In all kinds of iron the magnetisability of the material

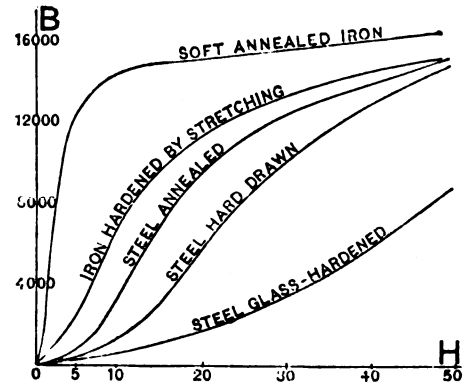

FIG. 14.—Curves of Magnetisation of Different Magnetic Materials.

becomes diminished as the actual magnetisation is pushed further. In other words, when a piece of iron has been magnetised up to a certain degree it becomes, from that degree onward, less permeable to further magnetisation, and though actual saturation is never reached, there is a practical limit beyond which the magnetisation cannot well be pushed. Joule was one of the first to establish this tendency towards magnetic saturation. Modern researches have shown numerically how the permeability diminishes as the magnetisation is pushed to higher stages. The practical limit of the magnetisation, B, in good wrought iron is about 20,000 magnetic lines to the square centimetre, or about 125,000 lines to the square inch; and in cast iron the practical saturation limit is nearly 12,000 lines per square centimetre, or about 70,000 lines per square inch. In designing the electro-magnets, before calculations can be made as to the size of a piece of iron required for the core of a magnet for any particular purpose, it is necessary to know the magnetic properties of that piece of iron; for it is obvious that if the iron be of inferior magnetic permeability, a larger piece of it will be required in order to produce the same magnetic effect as might be produced with a smaller piece of higher permeability. Or, again, the piece having inferior permeability will require to have more copper wire wound on it: for in order to bring up its magnetisation to the required point, it must be subjeted to higher magnetising forces than would be necessary if a piece of higher permeability had been selected.

A convenient mode of studying the magnetic facts respecting any particular brand of iron is to plot on a diagram the curve of magnetisation—*i.e.*, the curve in which the values, plotted horizontally, represent the magnetic force, H, and the values plotted vertically those that correspond to the respective magnetisation, B. In

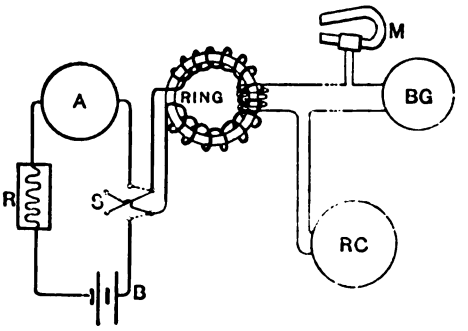

FIG. 15.—Ring Method of Measuring Permeability (Rowland's Arrangement).

Fig. 14, which is modified from the researches of Prof. Ewing, are given five curves relating to soft iron, hardened iron, annealed steel, hard-drawn steel, and glass-hard steel. It will be noticed that all these curves have the same general form. For small values of H the values of B are small, and as H is increased B increases also. Further, the curve rises very suddenly, at least with all the softer sorts of iron, and then bends over and becomes nearly horizontal. When the magnetisation is in the stage below the bend of the curve, the iron is said to be far from the state of saturation.

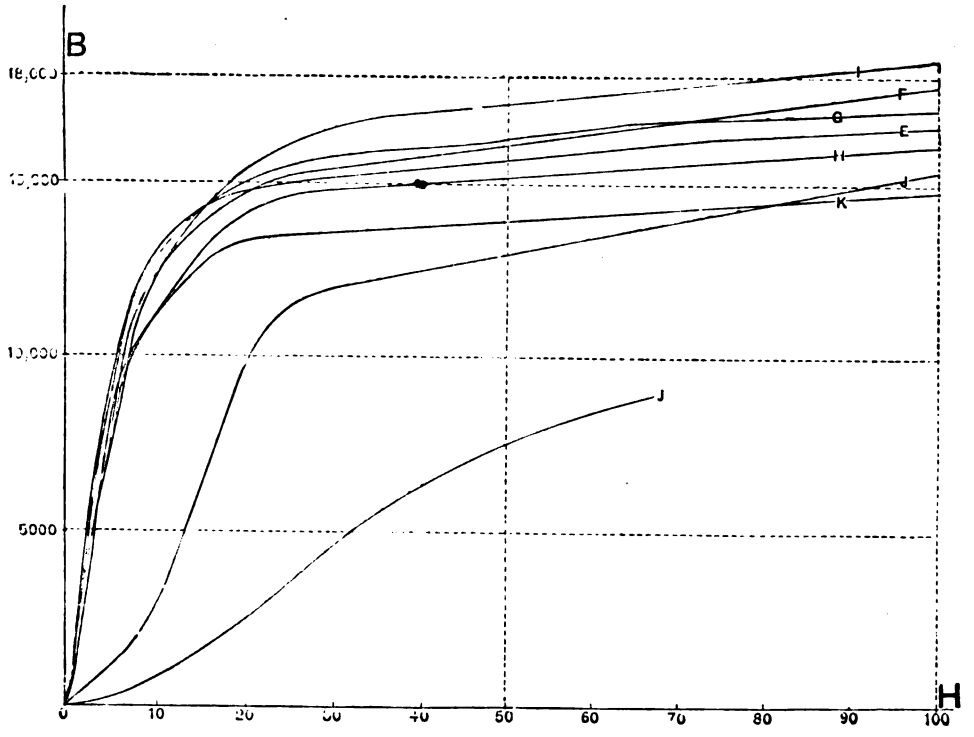

FIG. 16.—Bosanquet's Data of Magnetic Properties of Iron and Steel Rings

But when the magnetisation has been pushed beyond the bend of the curve, the iron is said to be in the stage approaching saturation; because at this stage of magnetisation it requires a large increase in the magnetising force to produce even a very small increase in the magnetisation. It will be noted that for soft wrought-iron the stage of approaching saturation sets in when B has attained the value of about 16,000 lines per square centimetre, or when H has been raised to the value of about 50. As we shall see, it is not economical to push B beyond this limit; or, in other words, it does not pay to use stronger magnetic forces than those of about H = 50.

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Methods of Measuring Permeability.

There are four sorts of experimental methods of measuring permeability.

1. *Magnetometric Methods.*—These are due to Müller, and consist in surrounding a bar of the iron in question by a magnetising coil, and observing the deflection its magnetisation produces in a magnetometer.

2. *Balance Methods.*—These methods are a variety of the preceding, a compensating magnet being employed to balance the effect produced by the magnetised iron on the magnetometric needle. Von Feillitzsch used this method, and it has received a more definite application in the magnetic balance of Prof. Hughes. The actual balance is exhibited to-night upon the table, and I have beside me a large number of observations made by students of the Technical College by its means, upon sundry samples of iron and steel. None of these methods are, however, to be compared with those that follow.

3. *Inductive Methods.*—There are several varieties of these, but all depend on the generation of a transient induction-current in an exploring coil which surrounds the specimen of iron, the integral current being proportional to the number of magnetic lines introduced into, or withdrawn from, the circuit of the exploring coil. Three varieties may be mentioned.

(A) Ring Method.—In this method, due to Kirchhoff, the iron under examination is made up into a ring, which is wound with a primary, or exciting coil, and with a secondary, or exploring coil. Determinations on this plan have been made by Stowletow, Rowland, Bosanquet, and Ewing; also by Hopkinson. Rowland's arrangement of the experiment is shown in Fig. 15, in which B is the exciting battery; S, the switch for turning on or reversing the current; R, an adjustable resistance; A, an ampere meter; and BG the ballistic galvanometer, the first swing of which measures the integral induced current. RC is an earth-inductor, or reversing coil, wherewith to calibrate the readings of the galvanometer, and above is an arrangement of a coil and a magnet to assist in bringing the swinging needle to rest between the observations. The exciting coil and the exploring coil are both wound upon the ring; the former is distinguished by being drawn with a thicker line. The usual mode of procedure is to begin with a feeble exciting current, which is suddenly reversed, and then reversed back. The current is then increased, reversed, and re-reversed; and so on until the strongest available points are reached. The values of the magnetising force H are calculated from the observed value of the current by the following rule. If the strength of the current, as measured by the ampere meter be i, the number of spires of the exciting coil S, and the length, in centimetres, of the coil (*i.e.*, the mean circumference of the ring) be l, then H is given by the formula:—

$$H = \frac{4\pi}{10} \times \frac{S\,i}{l} = 1{\cdot}2566 \times \frac{S\,i}{l}.$$

Bosanquet, applying this method to a number of iron rings, obtained some important results. In Fig. 16 are plotted out the values of H and B for seven rings. One of these, marked J, was of cast steel, and was examined both when soft and afterwards when hardened. Another, marked I, was of the best Lowmoor iron. Five were of Crown iron, of different sizes. They were marked for distinction with the letters G, E, F, H, K. In the accompanying table are set down the values of B at different stages of the magnetisation.

Table *of Values of* B *in Five Crown Iron Rings.*

Name.	G.	E.	F.	H.	K.
Mean diameter.	21·5cm.	10·035cm	22·1cm.	10·735cm	22·725cm
Bar thickness.	2·535	1·298	1·292	0·7137	0·7544
Magnetising Force.					
0·2	126	73	62	82	85
0·5	377	270	224	208	214
1	1·449	1,293	840	675	885
2	4·564	3·952	3,533	2,777	2,417
5	9,900	9,147	8,293	8,479	8,884
10	13,023	13,357	12,540	11,376	11,388
20	14,911	14,653	14,710	14,066	13,273
50	16,217	15,704	16,062	15,174	13,890
100	17,148	16,677	17,900	16,134	14,837

(To be continued.)

Titmaning.—The village of Titmaning, in Bavaria, of 2,000 inhabitants, is about to adopt the electric light. The necessary power will be derived from a fall on the Schlossbach.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 12, 1890.

The First Westinghouse Electric Railroad.—The first Westinghouse electric railroad was started a short time since in Lansing, Michigan, and has been in most successful operation. The Westinghouse Company has been so quiet about the matter that the appearance of the first working road was awaited with a great deal of interest, and some description of it may not be without interest. The Westinghouse motor car resembles as nearly as possible, to outward appearance, the Sprague and Thomson-Houston car now in use. Like them it uses an overhead system with under-running wheel trolley, precisely similar in its general characteristics to those already in use. The motors are centred on the axles and rest at the free ends on compression springs supported by the truck. There are two motors used on each car, each of 15 horse-power, and operating on a standard railway voltage of 500 volts. The mechanical construction of the motors is admirable. Especially appreciated by practical electricians is a device that admits of very ready removal of the armature by withdrawing bolts. The field-magnets are so hinged that they then open out to permit ready access to field coils and armature. The general appearance of the motor is very similar to that of the Thomson-Houston motor now in extensive use. The motors are inclosed in sheet-iron cases, and the driving gear connecting with the car axle runs in oil tight boxes partially filled with oil, so that there is most thorough lubrication, and much of the objectionable noise and wear is obviated. The motors are controlled by a switch handle moving over a dial, and the method of regulation is a combination of that used in the Sprague and Thomson-Houston systems. Three resistance coils, exterior to the motor, are used, and besides that, the fields have two sets of coils, either of which can be employed. In starting the car the three resistances are cut out, one after another, and then the fields thrown into action successively. This arrangement avoids the complication of the Sprague switchbox and some of the inherent difficulties of a complicated rheostat like that in use on the Thomson-Houston system. The details of winding and construction of the motors are, however, as yet, kept secret, and great care is taken to keep outsiders from getting much information as to the system. The overhead wire arrangement includes a bare trolley wire, suspended by the usual methods, and much the same method of feeding as is employed on the Sprague system. The operation of the Lansing Road has been very successful, in spite of a rather poor roadbed; and a single motor car, drawing one or two trailers, has repeatedly taken 250 people up a long 5 per cent. grade.

An Edison Electric Traction Motor.—Mr. Edison has recently taken the field with a new form of motor for traction work, or, more strictly speaking, a new method of regulation. He employs two motors driving the axle or axles of the car through their differential action upon an epicyclic gear. The motors are shunt wound, and extreme nicety of speed regulation is obtained, while under some conditions one of the motors will be acting as a dynamo, and hence minimising the losses of the system. The plan is not yet in practical use, but the patents have been recently issued.

The National Telephone Convention at Detroit.—The National Telephone Convention at Detroit has just closed after a successful meeting. A number of Papers dealing with the details of exchange construction and management were read. The most striking feature of the Convention, however, was the growing feeling in favour of complete metallic circuits. At the last meeting there was most bitter opposition to an open discussion of the metallic circuit question; but a year's experience seems to have done its work, and now it is freely admitted that the more modern system must come into very extensive use, and that the changes involved in working an exchange through metallic circuits are not nearly as formidable as were feared at an earlier stage of the art.

Electrical Nomenclature.—The American Institute of Electrical Engineers holds the first of its autumn meetings on next

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Tuesday, and the prominent question that will come up for discussion is the proposed nomenclature of certain electrical units. The Henry will hold a prominent place in the discussion, and some formal action will probably be taken by the Institute on its adoption. There is a rather general feeling, however, that in choosing a practical unit of self-induction, it should be made not to equal the earth-quadrant, but some convenient sub-multiple of it. American electricians do not take very kindly to Dr. Fleming's suggestion of abbreviating the aforesaid unit to "Hen;" it is considered somewhat too suggestive.

CORRESPONDENCE.

THE MAGNETISATION OF STEEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your abstract of the discussion on Mr. Preece's Paper on "The Magnetisation of Steel," read at the Leeds meeting of the British Association, Sir William Thomson is reported to have stated that the results obtained by Mr. Preece are enormously better than had previously been deemed attainable. I do not remember whether Sir William Thomson actually made that observation, and fancy that some remarks he made as to attainable magnetisations must have been misunderstood. In any case, much higher inductions have been obtained in previous experiments than any of those given in Mr. Preece's tables, although these are very valuable as giving data for a large number of different kinds of steel.

A considerable number of experiments on this subject were made by my brother Prof. T. Gray, and their results are given in two papers by him in the *Philosophical Magazine* for November, 1878, and December, 1885. An abstract of the latter paper is contained in my little book on "Electrical Measurements." In the first paper are results of experiments made with steel at different tempers, produced by quenching in water and oil, in the second magnetic moments of magnets having different lengths, but all nearly the same diameter.

The magnets used by my brother were made for use as deflectors for determinations of **H**, and were naturally much smaller than those experimented on by Mr. Preece. Four cylindrical magnets, each 8cms. long and ·25cms. in diameter, had an average magnetic moment of 52 (C.-G.-S.) per gramme, or an induction of about 5,700, while one, 3cms. long and of the same diameter, had an induction of about 3,300. I do not think that bringing the length of the last down to 2cms., which would have given about the same ratio of length to thickness as in Mr. Preece's magnets, would have reduced the induction so low as his highest number, 2,218.

Besides calling attention to these experiments by my brother, perhaps I may be pardoned for giving here just a few particulars regarding the experiments referred to by Sir William Thomson, which were carried out by myself some years ago under his direction. Several different kinds of steel were experimented on, and the results for steels by different makers, but of very closely the same composition, were widely different. The best result obtained was a magnetisation of about 100 per gramme, that is a magnetisation intensity of about 780 obtained in steel bars 60cms. long, and of square section about 1cm. in side. This, so far from being 10 per cent. or more below the inductions which Mr. Preece's experiments have shown to be obtainable, as the report of the discussion would naturally imply, is an induction of about 10,000 in a plain straight bar of glass-hard steel, a magnetisation approximating to that obtained by Prof. Perry in his horse-shoe magnet, with its magnetic circuit completed by a special armature.

The inductions for other steels ranged from about 3,000 upwards, with the exception of one particular tool steel, said to be of high quality, which was hardly magnetisable at all, or, at any rate, had scarcely any retentiveness. It was quite easy with the most magnetisable steel to obtain inductions of about 8,000, which were retained practically undiminished for long periods of time.

I should like also to call attention to an interesting Paper in the *Phil. Mag* for May, 1887, on "The Effect of Percussion and Annealing on the Magnetic Moments of Steel Magnets," by Mr. William Brown (formerly Thomson Experimental Scholar in the University of Glasgow, now Demonstrator of Physics in the Royal College of Science, Dublin). Mr. Brown used cylindrical magnets having lengths from 33 times to 37 times their diameters, and obtained inductions at glass-hard temper varying from 6,000 to 7,000. He showed that heating in an oil bath at a high temperature and cooling in air, enormously increases the loss of magnetic moment by percussion. This loss is very small when the magnet is glass-hard.

I should like to say, finally, that the most convenient expression of results, such as those above referred to, seems to me to be the intensity of magnetisation as ordinarily defined, that is, the magnetic moment per cubic centimetre, and not 4π times this quantity, or the "induction," which is favoured by so many experimenters, and which I have used above for the sake of comparison.—Yours truly,

A. GRAY.

University College of North Wales,
Bangor, September, 1890.

COMPARING CAPACITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to H. Casenhem's letter in last week's *Electrician*, the true capacity of the Porthcurnow-Gibraltar cable was taken, I believe, by Mr. Lilley to be that obtained by summing up the factory tests of the cable when in short lengths.

In my note on Saunders' Capacity Key, Figs. 3 and 6 are reversed. Fig. 6 shows the connections when both levers are *up*, not Fig. 3. On depressing the "discharge" lever, the connections become first, as shown in Fig. 3; then the condenser is put to earth, and immediately afterwards the galvanometer is inserted between the junction of the cable and condenser and earth giving the throw, α, from which the correction, v_2, has to be deduced. To obtain v_2 from α, proceed with both levers of the key *up*, and observe the throw on charging the cable and condenser together from a point on the slides a few studs from the zero end, as explained in the note.

It is assumed in the formula for this test that the whole of the conductor of the cable is at the same potential, viz., that of the junction of the cable and the condenser at the moment when the balance was obtained. Sufficient time to charge up the cable fully must, therefore, be allowed to elapse after the application of the battery before commencing to balance. Before the formula can be applied to the case of a cable of very low insulation, the average potential of the conductor will have to be calculated from knowledge of the conductor resistance and the insulation resistance at the time the balance was observed.

A comparison near enough for most purposes may be arrived at without wasting time in getting an exact balance by simply closing the galvanometer circuit (see Fig. 5) until no current is indicated (*i.e.*, until the potential of the junction of the cable and the condenser becomes equal to that of the point of application on the slides), and then afterwards depressing the "discharge" lever as before to obtain the correction, α. A high resistance, a megohm or so, in the galvanometer circuit facilitates the balancing immensely.

With an electrometer, the test is a perfect *null* method.—Yours, &c.,

ALEX. MUIRHEAD.

Laboratory: Cowley-street, Westminster, S.W.,
September 23, 1890.

THE "STOCKPORT" GAS ENGINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our attention has been drawn to the very interesting and practical paper, which appeared in your issues of the 1st and 22nd August last, on the "Lighting of London Theatres by Electricity," by Mr. Ed. C. De Segundo, and in which reference was made to two of our 16-horse nominal "Stockport" gas engines as supplying the power for the installation at the Lyric Theatre.

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With your permission, there are one or two points in that reference which we would wish to correct. As regards the consumption of gas by these engines, the "32 cubic feet per indicated horse-power," as mentioned, should be "*32 cubic feet per 'electrical' horse-power.*" This should be equivalent to 21 cubic feet of gas consumed per indicated horse-power.

The items representing "maintenance and wages" also, in the absence of explanation, appear excessive. This explanation may be found within the paper, where it says that "these engines run from 18 to 20 hours a day regularly." All practical men will quite understand that such forced work as here represented is the most expensive of all work. Besides, the circumstances under which these engines were erected were exceptional. They were constructed, erected, and running within four weeks from the date of the order, and, owing to this extraordinary pressure of time, they were not adjusted at the works in the usual way, but were made to work straight off from starting, *24 hours a day*, and continue to work at this pressure for many months with scarce a sufficient intermission for cleaning, to say nothing of adjustment.

Hoping you will insert these few lines for explanation, which we think are due to us—Yours, &c.,

TINSLEY WATERHOUSE, Secretary,
J. E. H. Andrew and Company (Limited).

TRADE NOTES AND NOTICES.

SALE BY AUCTION.—Messrs. Furber, Price, and Furber announce in our advertisement columns that they will sell by auction, at 42, Eagle-street, Red Lion-street, W.C., on Tuesday next, September 30th, a valuable electrical generating plant (Perreur-Lloyd's patent system), including reservoirs, primary and secondary batteries, vats, incandescent lamps, shades, carbons, porous cells, electrometers, wires, portable forge, vertical boiler, and other effects. Further particulars and catalogues may be obtained of the auctioneers, at their offices, Warwick-court, Gray's Inn, London, W.C.

MESSRS. GILL AND CO.—This firm have taken commodious offices in Parliament-street, Westminster, close to the Houses of Parliament.

BELL'S ASBESTOS COMPANY (LIMITED).—We are in receipt of an illustrated catalogue issued by this firm, which contains 66 large octavo pages of particulars and prices of the well-known manufactures of this firm, and includes a number of testimonials from firms using them. The catalogue is well got up, and is very comprehensive.

MESSRS. W. H. WILLCOX AND CO.—This firm have recently issued a new catalogue, descriptive of machine belting, fire engine and suction hoses, laces, belting fasteners, copper rivets, &c. The catalogue is well illustrated, and contains a mass of useful information for the electrical and engineering trades.

JAMAICA INDUSTRIAL AND MANUFACTURING EXHIBITION.—The contract for lighting this Exhibition has been secured by Messrs. Nicholson and Jennings, of 7, Westminster Chambers, Victoria-street, S.W., who have tendered in accordance with the specification prepared by Mr. Kenneth Mackenzie, of 15, Great George-street, Westminster, who is acting as consulting engineer to the Commissioners. The Exhibition will be opened in January next, and will remain so for at least three months, and being the first Exhibition held in that part of the world, it is naturally creating considerable attention. The contract includes motive power and plant for an equivalent of 70 arc lamps, and 650 glow lamps, or equal to an electrical output of 74,000 watts; and since the buildings which are being erected will be spacious and of an elegant design, the effect both in the interior of the Exhibition as well as the ornamental grounds will be very striking. The contract also includes two electric motors of 20 horse-power each for running some of the counter shafting supplying power to exhibitors. The West Indies are at present certainly, as far as regards the enterprise of electrical contractors, altogether untouched; since the greater part of whatever has been done there up to now has been supplied from the United States, and it is thought that a considerable impetus will be given to trade by the fact of this Exhibition being organised by the Government of the largest English colony there. We understand that Mr. Mackenzie will be glad to give information and particulars to any electrical firms who might feel inclined to utilise the advantages which this Exhibition will offer for opening up a trade in the West Indian Islands and Central America.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

August 23, 1890.

13,276. E. SHINN. Liverpool. Improvements in covering wires to protect from corrosion, especially applicable to electrical conductors.

August 25, 1890.

13,319. J. TOWNLEY. London. Improvements in electric bells and motors.

13,337. G. FORBES. London. Improvements in electrical contacts.

13,344. H. J. ALLISON. London. Improvements in galvanic batteries (P. Hathaway, United States).

13,357. A. SIEMENS. London. Improvements in electro-motors.

13,358. A. SIEMENS. London. Improvements in the means for driving winches and other winding machinery by electrical motors.

13,359. SIEMENS BROS. AND CO. (Limited). London. Improved means for carrying electro-motors on electrically propelled cars or vehicles (Siemens and Halske, Germany).

13,362. E. EDWARDS. London. Improvements in automatic telegraphs (E. Cassalette and D. Kunhardt, Germany).

13,371. H. J. HARRIS AND W. H. POWER. London. Improvements in electric bells and indicators.

August 26, 1890.

13,410. F. STITZEL, C. WEINEDEL, J. H. EGELHOFF, M. SCHWARTZ, A. RENTLINGER, AND J. KRIEGER. London. Improvements relating to electric semaphores.

13,434. S. J. DAVIES. London. The Davies improved electric clock.

August 27, 1890.

13,463. J. MOSELEY. Manchester. Improvements in and connected with zincs for galvanic batteries.

13,485. W. WHITE. London. Improvements in fittings for electric glow lamp conductors.

13,491. C. B. HARNESS. London. Improvements relating to electric belts and to apparatus for use in connection therewith.

August 28, 1890.

13,522. G. ROUX. France. Improvements in instruments for indicating or registering the state of the charge in accumulators.

13,525. G. HOOKHAM. Birmingham. Improvements in electricity meters for alternating or interrupted currents.

13,535. N. G. THOMPSON AND G. H. REW. London. Improvements in electrical alarms.

13,557. T. S. E. DIXON. London. Improvements in secondary batteries. (Date applied for under Patents Act, 1883, Sec. 103, February 6, 1890, being date of application in United States.)

13,570. B. EGGER. London. Improvements in and relating to telegraphic apparatus.

August 29, 1890.

13,619. A. L. LINEFF. London. Improvements relating to magneto-electric conductors for traction purposes.

August 30, 1890.

13,635. W. P. THOMPSON. Liverpool. Improvements in or appertaining to electric welding (C. L. Coffin, United States).

13,636. W. P. THOMPSON. Liverpool. Improvements in electric welding (C. L. Coffin, United States).

13,683. O. ROMANZE AND F. W. WHITE. London. Improvements in electric switches.

13,699. F. H. BERRY. London. Improvements in electric bells or gongs.

September 1, 1890.

13,735. C. HOEPFNER. London. Improvements in apparatus for use in electro-metallurgical operations.

September 2, 1890.

13,746. H. CLEGG. West Norwood. Improvements in the manufacture of incandescent electric lamps.

13,751. C. W. HUNTINGTON. Manchester. Improvements in electric switches.

13,770. W. F. TAYLOR, G. B. LUCKHOFF and E. H. HUNGERBÜHLER. Harrow-on-the-Hill. Improvements in systems of electrical distribution of light and power by means of transformers.

13,774. F. C. DUNAWAY and F. W. DUNAWAY. London. Improvements in electrical connections.

13,780. W. R. ELLIOTT. London. Improvements in electric conduits.

13,790. H. H. LAKE. London. Improvements in conduits for electric conductors (H. N. Curtis, United States).

13,791. H. H. LAKE. London. Improvements relating to compositions and devices for use in the manufacture of filaments for incandescent electric lamps (V. M. Hobby, United States).

13,799. H. H. LAKE. London. Improvements in electrical signalling apparatus (Electric Secret Service Company, United States).

13,802. G. W. WALKER. London. Improvements in electrical measuring instruments.

13,807. C. M. REED. London. An improved battery compound.

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September 3, 1890.

13,845. J. L. HUBER and L. J. MAGEE. London. Improvements in and relating to the propulsion of tramway vehicles or boats by means of electricity.

13,853. C. A. FAURE. London. Improvements in the production of electricity and in means or apparatus therefor.

13,855. L. BERDON, G. W. BOURFIELD, and F. TEAGUE. London. Improvements in electrical and other meters.

September 4, 1890.

13,886. J. SWINBURNE. Teddington. Improvements in and connected with the distribution of power by alternating electric currents.

13,904. M. W. DEWEY. London. Improvements in and relating to electric railways.

13,905. M. W. DEWEY. London. Improvements in and relating to the welding of metals by electricity.

13,906. M. W. DEWEY. London. Improvements in and relating to the welding and brazing of metals by electricity.

13,921. A. SCHANSCHIEFF. London. Improvements in electric lamps.

13,943. C. T. B. BRIAN. Liverpool. Improvements in power-conduits for tramways or railways and in electrical connections therefor.

September 5, 1890.

13,987. J. RICHARD, F. RICHARD, and G. RICHARD. London. An electricity counter.

14,007. W. R. LAKE. London. Improvements relating to optical telegraphy and to means or apparatus for transmitting and printing the signs or signals used therein (G. Marzari, Italy).

September 6, 1890.

14,050. SIEMENS BROS. AND CO. (LIMITED). London. An improvement in electrical cut-outs (Siemens and Halske, Germany).

14,054. W. S. RICHARDS and G. B. JAMES. London. Improvements relating to apparatus for converting alternating electric currents into continuous currents.

14,066. C. POPPER. London. An improved electric bolt lock.

September 8, 1890.

14,090. A. J. JARMAN. London. Improvements in oil cans especially adapted for use on electrical installations.

September 9, 1890.

14,155. H. T. O. FRASER and J. W. BROWN. London. Improvements connected with switch-boards for telephonic systems.

14,156. H. ENGLAND. London. Improvements in electrical alarm clocks and watches.

14,168. F. FRASI. Blackheath. Improvements in tools for the making of splices in submarine and other telegraph cables, ropes, and cables.

14,181. W. ANDREWS. Nottingham. An improved electrical fog signal for railways, &c.

14,182. H. T. O. FRASER and J. W. BROWN. London. Improvements in or connected with telephonic switching apparatus.

14,186. C. G. PERKINS. London. Improvements in electric switches.

14,191. M. W. DEWEY. London. Improvements relating to electric railways.

14,193. R. LANGHANS. London. Improvements in means or apparatus for controlling, regulating, or automatically interrupting and indicating electric currents.

14,196. W. R. LAKE. London. Improvements in incandescent electric lamps (J. B. Tibbets, United States).

14,197. W. R. LAKE. London. Improvements relating to the use of electric motors and to the regulation or control of machinery operated thereby (the Thomson-Houston International Electric Company, United States).

14,202. W. R. LAKE. London. Improvements in apparatus for receiving payments, and for permitting the use of telephonic apparatus in exchange therefor (P. Bonamico, Italy).

14,204. G. C. LEVEY. London. An improved electric miners' safety lamp.

September 10, 1890.

14,232. R. KENNEDY. Kilmarnock. Improvements in magnetic circuits of dynamo-electric machinery.

14,255. W. LOWRIE and C. J. HALL. London. Improvements in or relating to the method of generating, transmitting, storing, and distributing electrical energy, and apparatus therefor.

14,259. H. A. CUTMORE. London. A new or improved switch to be used for a system of two or more speaking tubes.

14,260. H. H. HADDAN. London. Improvements in electric or magnetic carrier systems, otherwise known as port-electrics (J. T. Williams, United States).

14,269. R. D. RADCLIFFE. London. Improvements in electrical signalling apparatus, for police service and the like.

SPECIFICATIONS PUBLISHED.

1889.

13,168. MCCANDLISH. Electric lamps. (Price 6d.)

13,510. LAWRENCE. Electric lamps. (Price 8d.)

16,537. RYLANDS. Insulators for electric wires. (Price 8d.)

17,387. OULTON and EDMONDSON. Electric meters. (Price 8d.)

1890.

3,574. LOW and PRITCHETT. Distributing electricity. (Price 4d.)

7,871. HART. Electric signal circuit. (Price 6d.)

8,652. GREENE. Magneto-telephone systems. (Price 8d.)

11,025. JOHNSON (Higham Patent Right Company). Dynamo electric generators. (Price 8d.)

11,045. TAYLOR and LEAVENS. Printing telegraphs. (Price 1s. 1d.)

COMPANIES' MEETINGS & REPORTS.

The General Electric Power and Traction Company (Limited).

The statutory general meeting of this Company was held at Winchester House, Old Broad-street, on the 23rd inst., under the presidency of Viscount Bury.

The CHAIRMAN said: The task before me is purely a formal one, and I need not detain you at any length. You are aware that a statutory meeting such as this is only held for the purpose under the Act of giving any shareholder an opportunity of satisfying himself, by personal communication with the Directors at a short period after the operations of the Company have begun, that all the requirements of the various Acts have been complied with, that everything is regular and in due order, and that the Company is starting on its way with every legal requirement satisfied and complied with. I am happy to tell you that we are in complete order in that respect. There are no accounts before us. Naturally at this very early period of the conduct of

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PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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the company, it would be entirely premature either to talk about what had been done or about the immediate future. The time will shortly arrive when we shall have more to say on that subject. All I can tell you is that the Company, which began as a going concern, is now proceeding in a satisfactory manner, that we have been energetically and constantly occupied with looking into the various details of our factory, our mining plant, our launches, and our electric cars, which are all in their several departments in a satisfaetory position. Our electrical works have been placed under the management of Mr. A. T. Snell, who is well known as a most efficient and successful engineer, and who occupied a high position under Mr. Immisch, when he was manager at the Immisch works. We are very satisfactorily developing our mining plant, and we have orders—and very considerable orders—in that direction. We have also most satisfactory inquiries from various departments of electric traction, especially those devoted to tramways. In fact, we have a future before us, which, as I am not addicted to strong language, I will not call brilliant, but which is satisfactory to the Directors and to myself. I do not think I need add anything more. Of course, the object for which we are met is that the Directors and the shareholders should be placed in communication at an early period, as I said, of the history of the Company; and if any question occurs to any shareholder, I beg that he will now put it. I have only to repeat that the legal formalities consequent on the inauguration of the Company have all been complied with, and I have merely to announce that the statutory meeting is now being held, and to ask whether any shareholder has anything to say.

A SHAREHOLDER said he did not know whether the point was quite before them, but he thought that some statement as to how far the shares had been taken up might be furnished to them. They did not know—at least, he did not know—what the position of matters was in that respect.

The CHAIRMAN: That is not pertinent to a statutory meeting, nor do I think it is a regular question.

The SHAREHOLDER observed that he did not wish to press it.

The CHAIRMAN: I am particularly anxious not to go beyond the usual routine, as it is not advisable to do so; but I do not think that there can be any objection to my stating that, with the exception of £8,000, the whole of the shares have been allotted.

A SHAREHOLDER: Including the ordinary?

The CHAIRMAN: The ordinary and Preference. It may be satisfactory if I tell you that the whole of the proceeds of the Preference shares will be devoted to the working of the Company. I need not detain you any longer, I think, and the meeting is now prorogued.

The proceedings then terminated.

Direct Spanish Telegraph Company (Limited).

The following is the report and accounts of the Directors for the half-year ended June 30, 1890, to be presented at the general meeting of shareholders, to be held at Winchester House, E.C., on Tuesday, the 30th inst., at 2 o'clock.

The accounts show, after providing for debenture interest, a balance to the credit of profit and loss of £7,199. 17s. 2d. The traffic receipts have again been satisfactory, and show an increase of £2,057. 1s. 8d., as compared with the corresponding half-year of 1889. The working expenses are £391. 0s. 8d. in excess of those for the corresponding period of last year.

The Company's cables and the land lines in connection with them have continued in good working order throughout the half-year.

The Company was represented at the International Telegraph Conference held at Paris in May last, and had, as well as other Telegraph Companies and Administrations, to submit to reductions of tariff which will affect the Company's revenue to some extent. These reductions do not come into force until July 1, 1891.

An extraordinary general meeting will take place immediately after the ordinary general meeting, in accordance with the following resolution, which was unanimously adopted by the shareholders at the last ordinary general meeting:—"That in the opinion of this meeting the Directors' remuneration should be now increased beyond the sum of £400 per annum, and that in view of their declared intention not to avail themselves of their rights under the 71st of the Company's Articles of Association as it now stands, the Directors be, and are hereby requested to give notice of a special resolution being brought forward at the next half-yearly meeting for altering Article 71 so as to increase their remuneration to £600, or otherwise as may from time to time be voted in general meeting."

Of the balance of profit and loss, £2,500 have been put to the reserve fund, which now amounts to £20,258. 6s. 6d., leaving a balance of £4,699 17s. 2d. Out of this amount the Directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference Shares, and a dividend at the rate of 6 per cent. per annum (free of income-tax) on the ordinary shares. This will admit of a sum of £1,685. 12s. 9d. being carried to the "Contingencies Account," which the Directors consider it indispensable to maintain, in view of fluctuations of traffic, &c., the reserve fund applying solely to the renewal of the cables.

The dividend warrants will be issued on October 1st, 1890.

NEW COMPANIES REGISTERED.

ELECTRICAL INVENTIONS COMPANY (LIMITED).—Registered by A. W. Riscon, 10, Austinfriars, E.C., with a capital of £35,000, in £1 shares. Objects: To acquire by original application, assignment, licence or otherwise, and to develop, promote the use of, work, buy, sell, grant licences in respect of, assign, and deal with patents for electrical inventions and improvements, and electrical instruments and apparatus of every description, whether patented, secret or not, including any interest or partial right in or to the same, either in the British Empire or elsewhere.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 19th amounted to £1,640.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announce the payment on October 14th next, of interest of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum, on the Preference Shares of the Company, for the quarter ending September 30th, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income-tax, in respect of profits for the quarter ended June 30th. The register of transfers will be closed from October 7th to 14th, both days inclusive.

EASTERN EXTENSION TELEGRAPH COMPANY.—An interim dividend for the quarter ended June 30th of 2s. 6d. per share has been declared by the directors of the above Company, payable on the 15th proximo.

GLOBE TELEGRAPH AND TRUST COMPANY.—The Directors of this Company have declared an interim dividend of 1s. 9d. per share, payable on the 18th proximo.

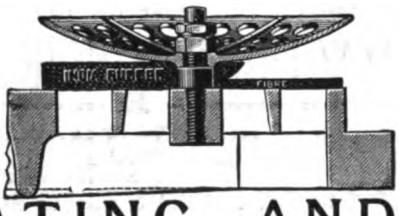
STOCK EXCHANGE.—The Committee have appointed this day (Friday) the 26th September, a special settling day in the shares of Elmore's Wire Manufacturing Company (Limited); and have ordered this security and the vendors' shares in Elmore's Patent Copper Depositing Company (Limited) to be quoted in the Official List. Application has been made to the Committee to appoint a settling day in, and to grant a quotation to, the International Okonite Company (Limited)—Preference shares Nos. 5,667 to 17,000, Ordinary shares Nos. 22,667 to 34,000, and £517,000 Six per Cent. Debentures; and Woodhouse and Rawson United (Limited)—Ordinary shares Nos. 1 to 31,416, and Preference shares, Nos. 40,001 to 54,285.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ending September 19, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,627.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated receipts of this Company for the half-month ended September 15th, amounted to £2,384, compared with £2,035 in the corresponding period last year, an increase of £349.

NEW VALVE

No Rubber, Percha, or Leather.



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"12, John-street, Sunderland, 26th Sept. 1885.

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For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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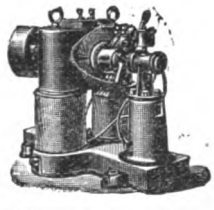
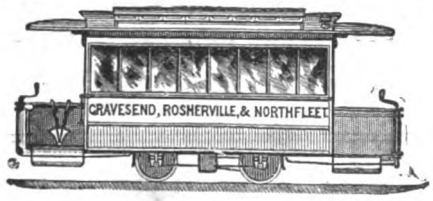
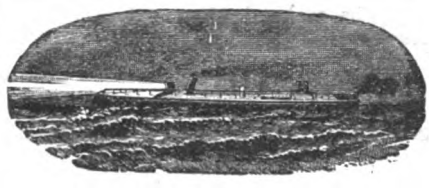
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 17.	Price Wednesday, Sept. 24.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 24. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
1,331,330	Stock	15/0	Anglo-American	51½ 52½	51 52	5 5 9	Jan., Apr., July, Oct	51¾	..
2,309,310	Stock	30/0	Do. Preferred	88 89	87½ 88½	6 4 4	,, ,,	88¾	88
2,309,310	Stock	..	Do. Deferred	15¼ 15¾	14¾ 15¼	..	..	15¾	..
25,000	£100	4%	African Direct, 4 per Cent. Debentures	98 101	98 101	3 19 3	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine	11¾ 12¼	11¾ 12¼	5 6 1	Mar., June, Oct., Dec.	12	11¾
69,200	100	5%	Do. 5 per Cent. Bonds	100 102	100 102	4 18 0	January and July ..	102	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103 107	103 107	4 13 6	June and December	..	..
$7,216,000	$100	..	Commercial Cables	.. 105	103 105	..	..	105	104
£16,000	£10	8/0	Cuba Submarine xd	12¼ 12¾	12 12½	6 16 0	February and August	..	..
6,000	10	10%	Do. Preference 10% xd	16½ 17½	17 18	5 11 1	,, ,,	..	..
12,931	5	0	Direct Spanish (£4 paid)	3¾ 4¼	4 4½	5 6 8	March & September	4⅛	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October..	9½	9⅜
60,710	20	3/6	Direct United States	10¼ 10¾	10⅜ 10⅝	6 11 9	Jan., Apr., July, Oct.	10⅝	10½
400,000	10	5/6	Eastern	14 14¼	14 14¼	4 11 3	,, ,,	14¼	14
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	,, ,,	15½	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	104 107	104 107	3 14 9	May and November	105¾	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	108	..
250,000	10	2/6	Eastern Extension	14⅛ 14⅜	14⅛ 14⅜	4 17 5	Jan., Apr., July, Oct.	14⅜	14⅛
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100 102	100 102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Aust'n. Gov.' Sub.) Debs. 1900	103 106	103 106	4 14 4	January and July ..	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102 105	102 105	4 15 3	,, ,,	..	..
180,227	10	4/3	Globe Telegraph and Trust	8¾ 9¼	8¾ 9¼	5 9 7	Jan., Apr., July, Oct.	9¼	8¾
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15	14⅜ 15	4 0 0	,, ,,	15	14⅞
150,000	10	5/0	Great Northern	15¾ 16¼	15¾ 16¼	4 12 4	Jan., April, and July	15¾	15½
15,000	100	5%	Do. 5 per Cent. Debentures, 1881	100 103	100 103	4 17 1	January and July ..	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883 xd	104 107	104 107	4 13 6	March & September	104	..
17,000	25	37/6	Indo-European	36 38	36 38	6 11 7	April and October ..	37	36½
33,348	10	4/0	London Platino-Brazilian	6½ 7⅛	6½ 7½	5 6 8	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures xd	105 108	103 108	5 11 1	March & September	..	..
9,000	8	6/0	Reuter's	8 8½	8 8½	5 19 4	April and October..	..	..
3,381	£100 Cert.	..	Submarine Cables Trust	113 117	113 117	5 2 7	,, ,,	..	..
15,600	£10	6/6	West African	9 10	9 10	5 0 0	.. ..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures xd	99 102	99 102	4 18 0	March & September	100½	99½
30,000	10	3/0	West Coast of America	4½ 5	4½ 5	10 0 0	January and July ..	..	..
150,000	100	8%	Do. Debentures 8%	101 106	103 108	7 8 2	June and December	106	103
88,321	10	Nil.	West India and Panama	3⅛ 3⅜	3⅛ 3⅜	.. ..	..	3⅜	3⅛
34,563	10	6/0	Do. 1st Preference 6%	11½ 12	11½ 12	5 0 0	April and October..	11⅝	11⅜
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	13½ 14	14 15	4 0 0	.. ..	14½	..
64,572	15	6/0	Western and Brazilian	11 11½	11 11½	5 5 3	May and November	11½	11¼
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6¾ 7	6¾ 7	.. ..	..	7	6¾
26,986	7½	4/6	Do. 5 per Cent. Deferred	4½ 5	4¾ 5¼	.. ..	..	5	4¾
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103 106	103 106	5 13 2	.. ..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101 104	101 104	5 15 5	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	122 127	122 127	5 10 3	May and November	..	..
£175,100	£100	6%	Do. 6 per Cent. Sterling Bonds xd	97 99	99 103	5 16 6	March & September	100½	..
			TELEPHONES.						
224,850	14/0	0/5¾	Consolidated Telephone Const. and Maintenance..	⅛ ¼	⅛ ¼	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	⅜ ½	⅜ ½	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅜ 4½	4⅜ 4½	6 3 1	June and December	4⅜	4⅜
15,000	10	0/0	Do. 6 per Cent. Cumulative 1st Pref.	12 12½	12 12½	4 16 0	June and December	12⅛	..
15,000	10	4/8¾	Do. 6 per Cent. Cumulative 2nd Pref.	10 10½	10 10½	5 14 3	,, ,,	10½	..
209,750	1	½	South of England, Ordinary	⅛ ⅜	⅛ ⅜	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd).	2½ 3	2½ 3	..	..	..	..
55,000	5	1/0	United River Plate	3½ 4	3½ 4	..	January and July ..	3⅝	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	.. ..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	.. ..	.. ..	..	.. ..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	2⅜ 2⅝	2½ 2¾	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4 4½	4 4½	..	..	..	..
42,853	5	..	Westminster Electric Supply	1 1½	1 1½	..	..	1⅜	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	1⅞ 2	1⅞ 2	..	..	..	..
63,416	2	1/2	Do. Preference	xd 1⅝ 1⅞	1⅝ 1⅞	..	..	..	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5¾	5½ 5¾	..	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction	7¾ 8¼	7¾ 8¼	..	..	8¼	7¾
46,700	2	10/0	Elmore's Patent Copper Depositing	6¾ 7¼	6 6½	..	..	7	6¾
20,000	5	..	Fowler-Waring Cables	3 3½	2½ 3	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works..	18½ 19½	19 19	5 5 3	February & August	18⅜	18⅛
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	102 104	102 104	4 6 7	.. ..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5¼ 5¾	5¼ 5¾	3 12 11	.. ..	5⅛	5⅛
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	43 45	5 6 8	March and July.....	44¼	43½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 102	100 102	4 18 0	.. ..	..	..







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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 646.—Vol. XXV. FRIDAY, OCTOBER 3, 1890. Price Fourpence.

NOTES.

The Convention of the National Telephone Exchange Association of the United States, attended by more than a hundred members, is an indication of the great differences which exist not only between the telephonic industries of that country and of our own, but of the dissimilar relations which prevail between the companies and officials of the American telephone systems and of those of England. At present such a Convention is hardly possible with us; nor if such a meeting could be held, would the Papers and discussions be of so frank and practical a character. There are some who would attribute this to the effects of our patent laws, and others would explain it rather by the selfish traits which are developed in those who have to deal with monopolies. Another factor is the relative areas of the two countries, which largely modify the bitterness of competing interests. The veil which hangs round the management of our telephone exchanges is seldom withdrawn by the reading of a Paper on the practical working or on the comparative merits of different methods of construction or of arrangement. It is true that a Paper of that kind would not be of such general interest as most Papers which are presented to our scientific institutions; and it must be admitted that the deliberations of the Congress at Detroit were not of a deeply scientific character. There is reason in the roasting of eggs, but there is singularly little science in the construction, and still less in the practical management of a telephone system, though there is a great field for ingenious switches and such devices.

The paradise of the telephone manager, according to the opinions expressed in the Papers and in the discussions, will be a dustless room fitted with a rustless switch-board. Those who decry our London smoke and fogs, and imagine that the clear, dry air which we hear so much about is always present in American cities, will be surprised to hear of the difficulties of keeping out dirt and damp from the contacts; and those who are not familiar with telephone switch-boards will learn with interest that carpets, curtains, open windows, and even fluffy dresses are inimical to the satisfactory working of a switch-board. As a contrast to our recent note on the wages of our telephone operators, it is pleasant to read that "on the same floor as the operating room a cloak room and lunch room should be provided. The lunch room should be equipped with tea and coffee urns, lunch table, &c. By providing such conveniences for the operators a better class of women become available, and exchange service correspondingly improved."

Notwithstanding the great care with which the action of the telephone has been studied, little is known as to the character of the movements of the membrane. The most successful attempt in this direction appears to have been made by Prof. Frölich, with the aid of manometric flames; and we gather from a Paper read before the Montefiore Technical Institute that his method of analysis is susceptible of several useful applications. The beautiful experiments in sound, in which vibrations are investigated by Kœnig's manometric flames, are well known, and have the characteristic that the motions of the membrane are indicated without the need of attaching any substance whose inertia would alter the vibrations under test. Many of the investigations made, during the last two or three years, on the exact mode of variation of alternating currents, have had the fault that the inertia of the moving parts of the testing apparatus has rendered doubtful the meaning of the results obtained. By making the telephone membrane one side of the manometric capsule this difficulty is overcome, as the resistance of the air or gas may be neglected. The form of the pulsating flame is photographed, the clearest results being obtained when the gas burnt consists of a mixture of bisulphide of carbon and protoxide of nitrogen.

Among the applications suggested are, the determination of the intensity of a current during its variable period of the charge and discharge of a condenser, the mode of variation of alternate currents, and the measurement of short intervals of time. It has even been attempted to measure the velocity of a bullet in the interior of firearms, without placing any obstacle in the path of the shot, as occurs in the chronographs of Siemens, Sebert, and others. The bullet contains a soft iron core; the barrel of the gun is surrounded along its entire length by a primary magnetising solenoid, and also at intervals with secondary coils connected with the telephone. The movement of the lines of force, as the bullet proceeds, excites currents in the secondary coils which affect both the telephone and the pulsating flame, and from the form of the latter the velocity of the bullet can be calculated. Good results have not yet been obtained because it is impracticable to obtain the images sharply defined; but the method is remarkably ingenious.

The question has more than once been asked: Why should the ohm be described by the dimensions of a column of mercury when such a resistance would be so difficult to construct, so troublesome to set up, and so inconvenient to use compared

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with a length of wire? An answer will be found in the consideration of the report of Mr. GLAZEBROOK "On Variations in the B. A. Standards," and in Mr. FITZPATRICK'S Paper on "The Specific Resistance of Copper." It was fully recognised, when the first B. A. standards were made, that changes might occur in them; and, as our readers are aware, they are from time to time compared with great care. It has been suggested that the most serious alteration which has taken place is due to the severe change of temperature to which the coils are subjected when they are brought down to freezing point. The wire being embedded in paraffin wax, the contraction due to the low temperature may give rise to a mechanical strain, and on this account it would appear advisable to make use of the very sensitive and accurate thermometric methods which we now have at our disposal, and to carry out the tests with a smaller range of temperature, thus avoiding the conveniently constant, but rather severe temperature of freezing. The modified form of coil suggested by Dr. FLEMING does not appear to meet with the approval of the B. A. Committee, since those who send in resistances for certification are invited to adhere to the old B. A. dimensions. Dr. FLEMING'S pattern offers several important advantages both as regards the state of the wire and its insulation. But even if the coil be constructed in the most approved shape, and be immersed in liquid paraffin instead of paraffin wax, there is still a considerable difficulty in the choice of a material of which the wire should be composed.

PLATINUM-SILVER, and similar alloys are convenient in having a small temperature correction, and an alloy has indeed been suggested which had a negative or even no temperature error whatever. One disadvantage of such alloys is that not only is it impossible to reproduce the exact mixture, but no two pieces cut from the same coil have the same properties. The production of a wire of any ductile pure metal, even if the temperature coefficient were considerable, would be an easy matter if only there were some method of relying on the similarity of different specimens. Given a standard metre, it would not be a very difficult or expensive matter for an experimenter in a distant colony to construct an accurate litre measure from which a kilogramme of water could be used as a practical standard of mass with an accuracy sufficient for all ordinary engineering purposes; but no such method is available whereby he can reproduce an ohm in the form of a wire. The "pure copper" of MATTHESON, which was for so many years the standard, became a merely arbitrary name when electrolytic copper was produced of "102 per cent. conductivity"; and the term now conveys less meaning than ever, when it is found that deposited copper is neither homogeneous or pure, and recourse must be had to chemical methods of the production of a metal which will perhaps be unsuitable for drawing into a wire, since the act of annealing it is liable to produce a chemical change.

IN accordance with the instructions of the Executive Committee of the Manchester Steam Users' Association, a series of experiments have been carried out by Mr. LAVINGTON E. FLETCHER, their chief engineer, to ascertain the result of injecting feed-water into a boiler when short of water, and with fires burning. These experiments, as may be readily understood, involved no little danger; but the results are very valuable, although they may not all be applicable in their present form to high-pressure boilers. Their principal object was to prove that the common idea that if feed-water be injected when the water in the boiler has fallen so low that the crown of the furnace is red-hot, a sudden and uncontrollable steam pressure will be generated which will blow the shell to pieces. The previous experience of the Association has been that explosions from shortness of water are rare, and that with internally fired boilers they are not very destructive. The furnace crown is rent, but the shell is uninjured, so that unless the attendant is standing directly in front of the furnace in a line with the rush of steam and water, but little injury need occur. Fatal accidents have taken place when attendants have discovered that the water was low, and were engaged in drawing the fire.

A FULL-SIZED mill boiler of the Lancashire type was laid down by the Committee on an open piece of ground, suitable barricades being erected, behind which were supplementary water gauges, pressure gauge, and indicators, showing movements of the furnace crowns. After numerous experiments, the red-hot state of the furnace crowns was indicated to the observers by the fusion of a zinc disc screwed to the plate, and connected with a wire strained by a counterpoise. This took place in some cases about 20 minutes after the water had been brought down to the level of the furnace crowns. The feed was turned on either through an ordinary dispersion pipe, or through one which was specially arranged to make the test more severe, by throwing the water directly on the hot plates. Not only was there no sudden rise of pressure, but on the contrary, the pressure at once began to fall in those experiments in which the safety valves were blowing, and even when these were fixed, and all the steam bottled up, the rise was by no means sudden or serious. The report, which contains several other results of great interest to engineers, does much credit to the Association, whose careful inspection of boilers insured by them, and whose readiness to give advice and information to all steam users, are so highly appreciated by those who have had dealings with them.

THE statements of our American correspondent this week with regard to some of the recent electric light accidents in the States bear out, what is indeed the general belief amongst those most competent to judge, namely, that these lamentable accidents are for the most part either grossly exaggerated, or due to the carelessness of the unfortunate victims.

Milan.—It is proposed to place a powerful projector at the top of the highest tower of Milan Cathedral.

Personal.—Mr. A. Grundy has retired from the firm of Baily and Grundy, and has joined the staff of the Gülcher Company.

The Martin Bi-Metallic Wire.—The Telegraph Administrations of Greece and Sweden have adopted the Martin bi-metallic wire for telegraph and telephone purposes.

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The International Okonite Company (Limited).—Notice is given that the statutory general meeting of the members of this Company will be held on Thursday, the 9th inst., at the Cannon-street Hotel, E.C., at 12 o'clock noon, for the transaction of the general business of the Company.

Worcester.—Mr. Pritchett, of Oxford-street, has been appointed to report as to the probable initial cost of providing and the subsequent expense of maintaining electric lighting works in Worcester.

The Florence-Fiesole Electric Tramway.—Telegrams from Florence state that, such is the state of public feeling, owing to the recent accident, that it is thought the electric cars will have to temporarily stop running.

Zurich.—At the last meeting of the Town Council, permission was given for the proposed enlargement of the Town Waterworks in connection with the supplying of the power necessary to light the public streets by electricity.

Lectures on Electricity.—Mr. W. Perren Maycock is now delivering courses of lectures on the theory and practice of electricity at the Pitlake Institute, Croydon, the Whitgift Grammar School, and the Merton College for Ladies.

Woolwich.—At the last meeting of the Vestry, Mr. Green moved, pursuant to notice, that the lighting of the Woolwich area by the electric light should be in the hands of the Local Authority. The motion was rejected by seven votes to four.

Society of Engineers.—The next ordinary meeting of this Society will be held at the Town Hall, Westminster, on Monday, October 6th, at 7:30 p.m., when a Paper will be read on "Sewer Ventilation," by Mr. W. Santo Crimp, Assoc.M.Inst.C.E., F.G.S.

Electric Traction.—Experiments with an accumulator car undertaken by Messrs. Hostmann and Co., of Hanover, in conjunction with the Oerlikon Company, on the line of railway, 20 miles long, connecting Hildburghausen, Heldberg, and Friedrichshall, have been satisfactory.

The Production of Oxygen (A Correction).—On p. 571 of our last issue we stated that M. Schemer-Kestner estimated that about 36 francs' worth of coal was used in producing one kilogramme of oxygen by the electrolysis of water. This figure obviously should have been *·36 francs' worth.*

Lewes.—A public meeting of the Lewes ratepayers was held in the Corn Exchange on Wednesday evening to consider the question of improving the lighting of the public streets. No decision was come to, and the meeting adjourned for a fortnight in order to give the ratepayers time to think the matter over.

Telephonic Extensions.—On Tuesday last a further extension of the system of the National Telephone Company was marked by the opening of telephonic communication between Birmingham and Stafford. At Stafford, after the line had been formally declared open, vocal and instrumental music was transmitted from London.

Godalming.—The Electric Lighting Committee of the Godalming Town Council have reported that in their opinion the time has arrived when the electric light might be safely adopted, if thought desirable, on financial grounds. A canvass of the town will be made to see how many are inclined to use electricity for private lighting.

Magnetic Charts.—M. Th. Moureaux, of the Saint-Maur Observatory, who is engaged in much the same work with regard to France as is being carried on in this country by Profs. Rücker and Thorpe, recently called attention in the *Journal de Chimie et de Physique* to the anomalous behaviour of the isogonic line passing through Hazebrouck and Clermont. This line, it seems, deviates from its proper path to run through Paris, and only regains its normal direction near Chartres.

Technical Education in Austria.—The governing body of the Technologisches Gewerbe Museum of Vienna has decided to institute an electro-technical school, where a four years' theoretical and practical course will be given. The course is intended for youths not less than 14 years of age who are desirous of qualifying for the higher ranks of working electricians. It is anticipated that the school will be opened during the present autumn.

Chester.—At the annual conversazione of the Chester Society of Natural Science and Literature, which took place at the Town Hall last week, the Council Chamber, which was devoted to a microscopical exhibition, was lit by the electric light. More interesting still, however, the microscopes themselves were illuminated by incandescent lamps. The temporary plant was lent by the Manchester Edison-Swan Company. The work of fitting up the installation was done by Messrs. Fawcus and Cowan.

The Glasgow Tramway System.—As we stated in our issue of July 4th there is a probability that the Glasgow tramway system, which is owned by the Corporation, will at the expiration of the present lease (July 1, 1894) be actually worked by the municipality itself, and electric traction seems in that case likely to be adopted. How extensive the Glasgow system is may be seen by the fact that the cars run something like 4,000,000 miles per annum, and carry over 40,000,000 passengers.

Insulation Formula for Cables carrying High-Pressure Currents.—In a recent issue of *La Lumière Electrique*, M. Jacquin gives the following formula for the insulation resistance of cables carrying high-pressure currents :—$M = \rho \frac{1}{E}$, in which ρ is the total insulation resistance, l the total length in kilometres, and E the pressure in volts. The coefficient M is 400,000 ohms per volt per kilometre of cable used; and M. Jacquin considers a cable to have become unsafe if M has decreased to 10,000 ohms per volt per kilometre.

Brussels.—The electrical plant at the Tudor accumulator station in the Passage du Nord comprises one 40 kilowatt and two 16·8 kilowatt 140 volt dynamos, which supply current to a battery of 264 Tudor accumulators, arranged in four groups of 66 cells each. The cells have a capacity of 756 ampere-hours, with a maximum discharge current of 126 amperes. The station can supply 2,000 16 candle-power lamps. The wires, which are of phosphor-bronze, are run overhead. The station is provided with an electric alarm, which warns the electrician in charge whenever the difference of potential on the mains varies by 1 volt.

A Meritorious Telegraph Operator.—M. Emile Laurent, 1st class telegraph operator in the French Soudan service, has just been promoted for distinguished service. In April, 1886, during an Arab incursion, Laurent sheltered the women and children of the village of Bakel in the telegraph station, and, aided by six native soldiers, beat off all the attacks of the Arabs. In May of this year, accompanied only by one assistant, Laurent followed in the steps of a flying column sent in pursuit of 4,000 Arabs, and repaired in four days 100 kilometres of wire destroyed by the enemy. Owing to the commander of the column being so rapidly placed in telegraphic communication with his base, he was able to take measures which ended in the complete defeat of the Arabs.

Electrical Glass Breaker.—The Pittsburgh *Dispatch* states that several glass factories are now using electricity for a novel purpose. Heretofore, when they wanted to cut one of the large cylinders of window glass, a simple but primitive method was used. This consisted of the pulling out from the furnace of a thin strip of glass heated white. This was quickly wrapped around the bottle-shaped end of the cylinder, and it melted through or fractured the glass. By the new method the glass cylinder is encircled with a fine wire, the extremities of which are put in connection with a small electric battery. When a current of electricity is passed through the wire, the latter becomes red hot and heats the glass beneath it. Then a single drop of water deposited on the heated place will cause a straight break of the glass clear around the path of the wire.

Projected Canal at Rheinfelden.—The plans for the construction of a canal between Beuggen and Rheinfelden have been approved of by the Bavarian and Swiss Governments. According to this project a company of Swiss manufacturers will apply two-thirds of the waters of the Rhine (measured at low water) to driving an electric power station. The amount of water passing down the river at this point has been found to be 300 cubic metres per second (1 cubic metre = 35·3 cubic feet) at the minimum. The company will draw off 210

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cubic metres per second for its turbines, and the Bavarian Government has stipulated that 30 cubic metres are to be supplied free for agricultural and manufacturing purposes; so that when the water is at low level, 60 cubic metres per second only will be left in the original bed of the river. The canal will be three kilometres long, and will drive double turbines of 1,000 horse-power.

Long Distance Telephony.—On Monday evening last the Manchester Field Naturalists' Society—presided over by Mr. Alderman W. H. Bailey—and many members of the Corporation, met at the Manchester office of the National Telephone Company; and a lively discussion took place on the effect of town fog on animal and vegetable organisms, between Dr. Baily, of Owens College, and Mr. Oglesby (Manchester), and Colonel Mackenzie, superintendent of Epping Forest, Dr. Charles Roberts, Prof. R. Meldola, F.R.S., and Mr. Philip Hartog, at the London offices of the Company in Oxford-court. The Berliner transmitter and the Bell receiver were used; and the voices of the Manchester members were heard quite distinctly in London, and easily recognisable. After the formal proceedings were over, the London office was connected with the Princess's Theatre, Manchester, and the Manchester office with the Savoy Theatre.

Proposed Hydro-electric Power Station at Lyons.—In Lyons the number of domestic manufactures is very great, so that it offers a promising field for the distribution of power by electricity. A project to make use of the water power of the Rhône is now being inquired into by the Government. The promoters of the scheme have constituted themselves into a syndicate (Syndicat Lyonnais des forces motrices du Rhône), and they propose to spend nearly three-quarters of a million sterling in digging a navigable canal 18·6 kilometres long, and establishing a hydro-electric generating station, having an output of 12,800 horse-power. It is estimated that a charge of about 125fr, per horse-power year will yield a fair return on the capital outlay. Hitherto considerations connected with the navigation of the river have prevented any utilisation on a large scale of the Rhône waters; but the present scheme overcomes that objection by the construction of the navigable canal.

Paris.—There was a curious scene in Paris the other day just outside the Opera House, says a correspondent of the *Daily News*. Traffic was in full swing, when a lady who was crossing the street and had got on to one of the refuges sunk to the ground with a scream. She had put her foot on a large metal plaque, and immediately felt an electric shock. The usual crowd collected, and the usual police arrived. But the cause was clear to all. Quite close to the scene of the accident was an electric light standard. With great presence of mind the police sent for several electricians, keeping a cordon in the meantime round the plaque. The experts went to work quickly and cautiously. The metal plate itself was raised. It communicated with one of the subterranean passages that lead to the drainage system of the city. Then at last the cause of the accident was discovered. A workman employed in the drains wanted to emerge, and happened to push up the plate at the moment the lady's foot was on it. Hence the shock.

Electricity as Applied to the Extinction of Fires.—In a Paper recently read before the Firemen's Convention at Detroit, Mr. H. L. Lufkin sketched several methods by which electricity might be made use of in extinguishing fires. In each large block of buildings he would have an electric motor geared to a powerful pump connected to the water mains, the motor being actuated from various points in the block by means of switches which close the circuit of the coils of a powerful electromagnet attached to the starting gear of the motor. It would not then be necessary to drag heavy fire engines through the streets, light hose carts only being necessary. The block would, of course, be fitted with a network of water pipes, valves, &c., and the motor would obtain its current from the mains of an electric supply company. Mr. Lufkin also proposed that instead of automatic sprinklers, whose action is frequently "too previous," sprinklers should be fitted in theatres and similar buildings in connection with a system of waterpipes, as described above. Switches could be placed at various points in the building, by the turning of which the electric pumping apparatus could be started, and the valve of the appropriate sprinkler opened.

Municipal Rapid Transit Statistics.—The following figures are taken from a Paper recently issued by the United States Census Bureau. In the 50 odd towns of the United States having a population of over 50,000, the total mileage of the street railways was 1,689 in 1880, and 3,151 in 1889, or an increase of over 86 per cent. The total mileage of 1889 was made up as follows:—

	Miles.	Per cent.
Animal power	2,351	74·62
Electricity	260	8·26
Cable	256	8·12
Steam (elevated roads)	62	1·96
Steam (surface roads)	222	7·04
Total	3,151	100·00

These figures, says the *Electrical Engineer* of New York, show that in 56 leading cities electric railways only form 8·26 per cent. of the total—a respectable figure, it is true, but still small. On the other hand, the figures for the whole country have been shown to be very different. They run thus:—

Miles of horse railway	5,902½
Miles of electric railway	1,753
Miles of dummy railway	556
Cable	441
Total mileage	8,652½

Taking the whole country, therefore, electric railways already form more than 25 per cent. of the total mileage.

The Interactions of Circular and Longitudinal Magnetisations.—In a short Paper communicated to the September number of the *Phil. Mag.*, by Prof. C. G. Knott, of the Imperial University, Tokyo, are given the results of some investigations undertaken by him on the effect of a current passing along a wire upon its apparent longitudinal permeability. The results of previous investigators, says Prof. Knott, would lead one to expect that a diminution of longitudinal intensity would be an evident accompaniment of a steadily sustained circular magnetisation; and this has been fully established in Prof. Knott's experiments. The wire to be experimented with was carefully annealed and then inserted as the core of a solenoid of copper wire of 138 coils per centimetre length. The wire and solenoid lay magnetically east and west. The current, which was about two amperes, entered the iron wire at the end furthest removed from the magnetometer and returned along two copper wires stretched parallel to the iron wire and very close to it. The results plotted out as curves show clearly that the linear current modifies the properties of iron in relation to the magnetic after-effect in three well-marked ways. First, there is a diminution in susceptibility. Secondly, when the linear current is flowing, the average magnetic intensity over a whole cycle no longer corresponds to the condition of zero polarity, as in the normal case when no linear current is flowing. For the one current, the magnetic intensity oscillates, so to speak, about a large positive polarity; and for the current in the reverse direction it oscillates about a nearly equal negative polarity. Thirdly, the curves, with the linear current in opposite directions, are no longer symmetrical on the side of the zero-line of magnetic force. A current passing along an iron wire, which is being magnetised, diminishes, as stated above, the apparent susceptibility of the wire; but this effect is more pronounced when the wire is acquiring a longitudinal polarity in the opposite direction to that in which the linear current is flowing. Hence, during any cyclic operation, the wire tends to acquire an average polarity in the same direction as that in which the current flows. These effects are more pronounced the stronger the linear current is as compared with the magnetising field. In a moderate cyclic field the effect of the linear current may be so strong as to prevent the wire ever acquiring other than one kind of polarity. In the course of these experiments it was noticed that if, before the wire has been magnetised at all, a current is passed along it, no appreciable longitudinal polarity is produced. Suppose, however, that the wire has been pretty strongly magnetised and then demagnetised by reversals, then, by simply passing a pretty strong current along the wire, a very pronounced polarity will be evidenced.

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ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 409.)

§ 12. **Westinghouse Transformer System.** — In the last four years, beginning in 1886, the Westinghouse Electric Lighting Company has developed in the United States an immense industry in the manufacture and erection of alternating-current plant for distribution of electric energy by transformer systems. At the present date (1890) there have been established by this Corporation in America about 300 central stations, comprising a total of over 500,000 16-candle-power incandescent lamps operated by alternate-current transformers. The several portions of this system have been designed with great care, and the mechanical and electrical construction of all parts has been brought to a high level of perfection. The standard type of alternator is represented in Fig. 30. In this alternator the revolving portion constitutes the armature, and the stationary magnets the field. The field-magnet is composed of a series of radial magnetic poles projecting inwards from the interior of a ring-shaped frame. These magnets are arranged to have alternate polarity at the inner ends. The magnet cores are formed of solid or laminated wrought iron, bolted to the inner circumference of a cast-iron cylindrical frame. On these cores are slipped exciting coils wound on shells, which are held in position by bolts at the extremities. These field-magnet poles are excited by the current from a small continuous-current dynamo. The armature revolves in the cylinder space in the centre of these radial magnetic poles. The armature core consists of a drum-shaped mass of laminated soft iron, built up of sheet-iron discs, compressed and secured to the steel shaft. On the surface of this drum-core are laid flat coils of insulated wire wound on formers, and laid on side by side, so as to clothe the drum with a layer of insulated wire coils. The ends of these flat coils of wire are bent over the flat ends of the drum, the whole set being secured by wire-binding (*see* Fig. 31). The number of coils on the drum is equal to the number of radial magnetic field poles. The coils on each half of the drum surface are joined in series and the two series connected in parallel, the diametra terminal wires coming to collecting rings on the shaft. The armature can be easily removed for repairs by lifting the upper half of the ring shaped iron frame of the field, and then taking the armature and shaft out of the bearings. These bearings

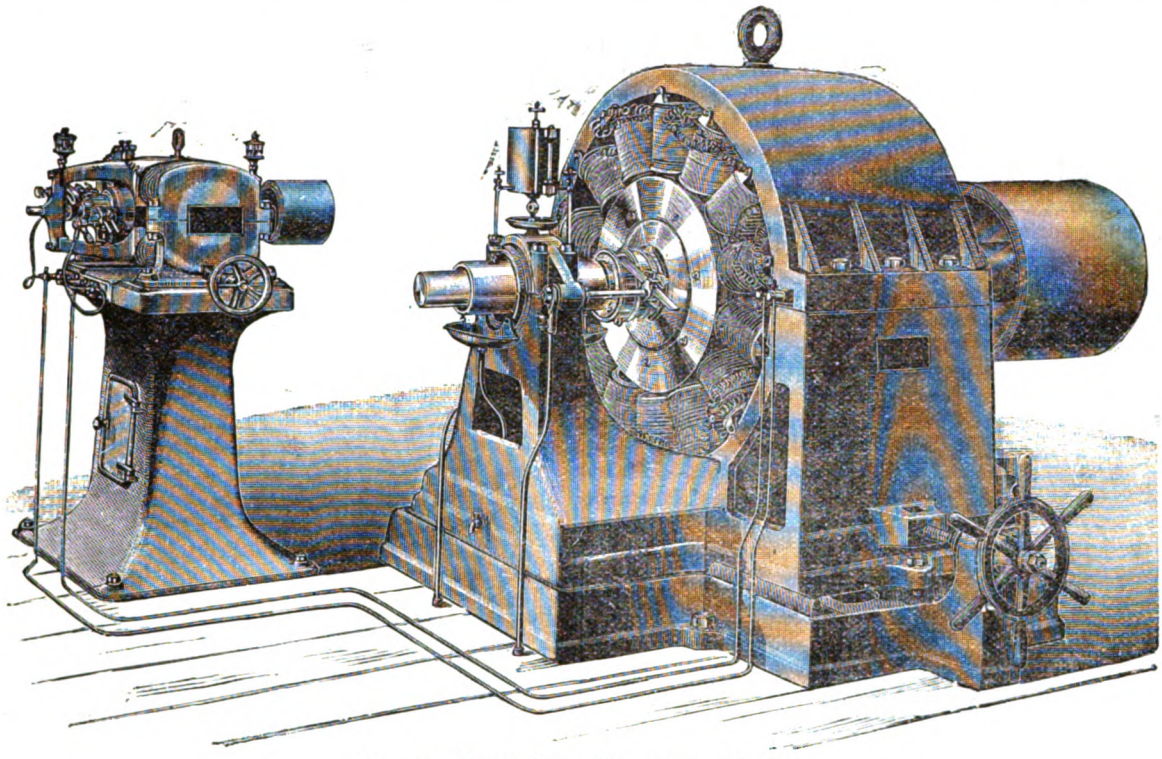

FIG. 30.—Westinghouse Alternator and Exciter.

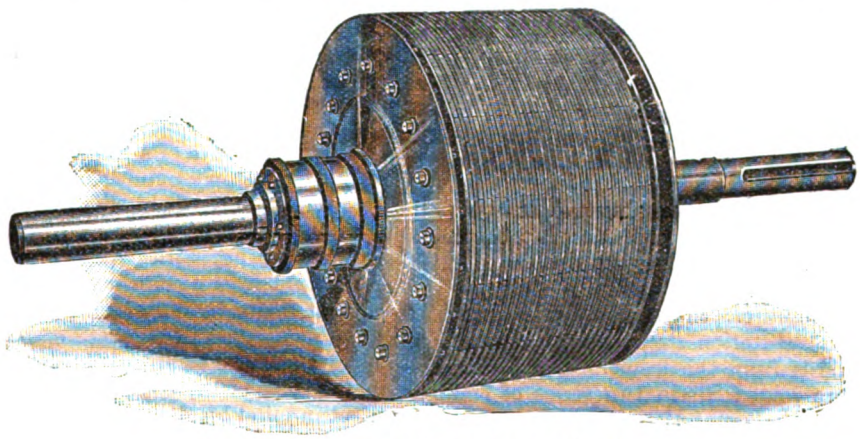

FIG. 31.—Armature of Westinghouse Alternator.

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are ball-bearings, a section of which is shown in Fig. 32, and oil is fed from sight-feed oil cups to them, and working out into a drip pan, flows thence into a tank cast in the hollow base of the dynamo, from which it can be drawn off and re-used. The dynamo rests on a cast-iron base, and has the necessary belt-tightening arrangements.

This dynamo is manufactured in five sizes—

No. 0,	500-lights,	floor-space 4ft. 2in. × 5ft.
No. 1,	750-lights,	floor-space 5ft. 2in. × 5ft. 6in.
No. 2,	1,500-lights,	floor-space 7ft. 4in. × 7ft.
No. 3,	3,000-lights,	floor-space 8ft. × 7ft. 6in.
No. 4,	6,000-lights,	floor-space 11ft. × 8ft. 4in.

The capacity being reckoned in 16 candle-power lamps.

In large stations, in place of having an exciter for each machine, it is usual to excite an entire battery of dynamos from one or two large exciters driven by separate engines.

The armatures of these dynamos are all wound to deliver current at 1,000 volts. On the 750-light size the total weight of copper on the armature is 16lb., and as it is disposed in a single layer on the surface of the drum it is readily kept cool and well insulated.

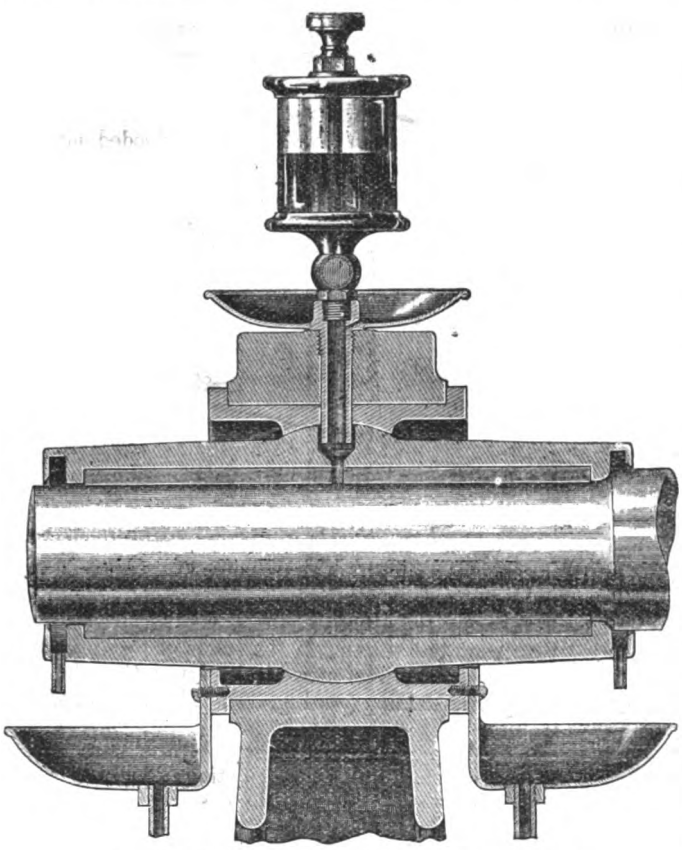

Fig. 32.—Ball Bearings of Westinghouse Alternator.

The leading-out wires from the collectors are carried on lugs on the main-bearing caps. The number of complete periods per second, or the frequency of the alternation of the current, is 130, or 8,000 per minute. Hence there are 16,000 alternations or reversals of current per minute. The usual speed of revolution is 1,000 per minute. In the No. 3 size, which is a commonly adopted central-station size, there are 16 magnet poles projecting inwards from the frame. The exciting coils of these magnets are joined up in two series of eight coils, on the upper and lower halves of the ring frame respectively, and the two series of magnet coils are joined up in parallel. These magnets are excited by a continuous current of about 25 to 30 amperes, supplied at 100 volts. The armature coils are joined up in a like manner.

The diagram in Fig. 33A* will indicate the manner in which these armature coils are connected, and Fig. 33B will show how the ends of the flat armature coils are turned over the flat end of the drum core to get them out of the way. The centre of the flat coil is occupied by a wooden lathe or core, and a narrow wood slip is inserted between adjacent coils. The whole armature when clothed with coils is wound round with steel piano wire. The clearance space between the surface of the wire and the end surface of the magnet poles is very small. Hence the wire moves in a very strong field. In operating a

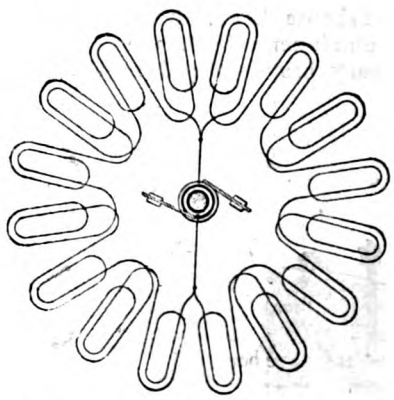

Fig. 33A.—Diagram of Winding of Westinghouse Armature.

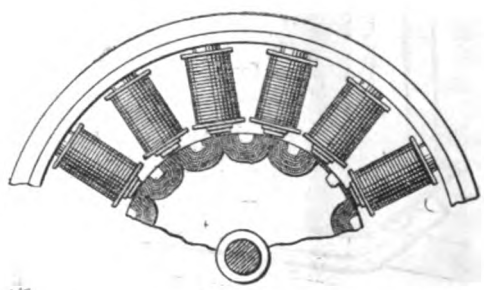

Fig. 33B.

battery of central-station dynamos, the whole of the field circuits of the alternators are joined in parallel with the armature circuits of one or more exciting dynamos operated by independent engines, the field-circuit of each alternator being controlled by a double-pole switch on the switch-board.

(To be continued.)

* These diagrams are from the British Specification, No. 9,726, of 1887. See also Brit. Spec., No. 9,725, of 1887.

THE ELECTRIC LIGHTING OF A MODERN MAN-OF-WAR.

Electric lighting afloat, especially on board men-of-war, differs in certain details from lighting ashore; and, although ship installations are confined to a small area, they have a good many enemies to contend with, not least of which is the inquisitive ignorance of a large population.

In wiring a ship a number of most important considerations arise, peculiar only to ship-life—circuits have to be arranged, and dynamos placed so as to combine convenience in peace time with the necessities of war; the chances of flooding a compartment from a collision or other accident; the danger of damaging mains by fire from the combustible matter carried in store-rooms, the "sweating" of bulkheads and the sides of the ship; and the enormous adjacent earth in the iron of the ship, are some of the points which have to (or rather should) be kept in mind by the electrician who wires a modern fighting ship. It would not be proper to publicly discuss the efficiency or otherwise of the existing arrangements, but a few remarks on fitting up, installation, and the management of circuits on board ship will not be without interest, and perhaps benefit, in these times, when auxiliaries to the navy in time of war will undoubtedly be drawn from our fine mercantile marine.

Dynamos.—Dynamos for sea service are naturally of low constant potential, usually about 80 volts, and of varying current capacity, from 200 to 400 amperes, according to the size of the ship. Their position depends on their number, that

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is to say, a reserve of power sufficient to work all the important lights must be placed below the water, or protected by armour, any additional power can be placed in more airy and convenient places above the water line; this, of course, is the supply usually employed in peace time, the lower or war dynamo room being chiefly, from its necessarily high temperature, used but little except in cases of necessity.

Switch-board.—The main switch-board, of course, is placed in the lower dynamo-room, well protected. It does not of itself call for much remark. Its requirements are as follows:—To enable one to put all or any of the circuits on to any machine, and to enable one to effect such a change of circuits or machines with rapidity. To provide each lead with a cut-out, to carry up to 200 amperes in each circuit without heating, to have a quick cut off to prevent fusing at the contacts. The return board should never be, as often is the case, a common return bar, with plugs to each circuit; each circuit should be as separate on the return as in the main. There are two important reasons for this. As regards the incandescent circuit, there is a danger of reversing the polarity of one machine, and, with earth in the circuit, 80-volt lamps have been known to have been worked by the two machines in series at 160 volts. Fig. 1 shows such a case, where half the lights are working at 80 volts, the others at 160 volts. The second inconvenience is caused when working arc lights, such as search lights, off the same board as incandescents. Often the search lights have to be kept ready for immediate use night after night; to avoid unnecessary wear and tear it is customary to run the dynamos for them slow, to keep them just excited; and with the return plugged up, it is an even chance that the polarity is reversed, therefore, of course, the crater forms in the wrong carbon, and the leads have to be shifted. It is for reasons such as these that the common return board is such a curse in practical use.

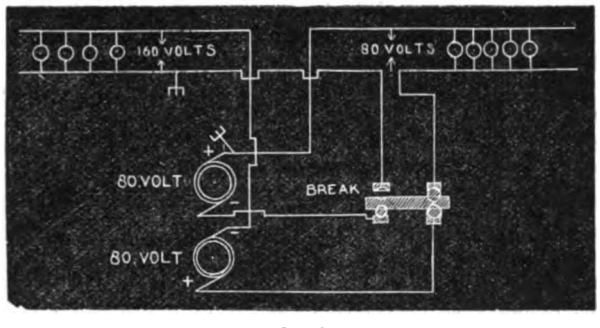

FIG. 1.

Wiring.—The next thing to consider is the wiring of the ship. In order to know how to wire a ship conveniently, *i.e.*, conveniently for future use, not conveniently for putting up, practical knowledge concerning the general disposition of the watertight compartments, the position of longitudinal and transverse bulkheads below the water relative to the decks above, and the distribution of the protective armour is required, as well as an insight into the ordinary routine of daily life on board ship. For instance, it is useful to know the various store-room lights and deck circuits which are switched on and off together at stated times, as well as the compartments whose watertight doors are closed every evening. The bearing of these points on the grouping of lights, and position of switches and cut-outs, is obvious, especially to the person who happens to have the main cut-outs of the bow and steaming, or other important lights, boxed up in a watertight compartment below. It is quite impossible to enter into details as regards these points, each ship varies so much in essential details of sub-division and construction that the most we can do is to broadly discuss the subdivision of lights in modern ships.

Sub-Division of the Lights.—There are two leading principles in the division of lights (one of necessity, the other of convenience). Firstly, the vital parts of the ship, such as the engine and boiler rooms, the magazines, and all protected fighting positions should be on mains of their own, with no submain or branch wires leading in unprotected places. This is necessary, as a short circuit in a branch may cause the main cut-outs to go, and so reduce an important part of the ship to darkness and confusion. Secondly, all lights which are exposed to the weather, such as the upper deck lights, which are particularly liable to leakage from wet and exposure, should be on a separate circuit to the lights between decks. A convenient way of subdividing lights in a large ship will probably be found to be as follows:—

(1) Engine and boiler rooms.
(2) Magazines, shell rooms, and other war store rooms.
(3) After accommodation and store rooms.
(4) Fore accommodation and store rooms.
(5) The central portion of the ship, with mains for upper deck.

Now, having decided the subdivision of lights, a few words about the leads of the mains. Naturally, as far as possible, they should be led below the water line, avoiding all store-rooms where inflammable material is kept; for it would greatly add to the danger of a fire to be at that time deprived of the usual method of lighting. It will also often be found necessary, on account of the space occupied by the mains (for the search light as well as the incandescent mains have to be led along, and the latter should be separated so as to have only one lot disabled in case of accident), to lead half the mains on opposite sides of the ship. As the mains arrive at their respective lighting areas a most important point arises which affects all ships, whether war or merchant vessels, namely, as to how the submains should be forked in.

Cut-outs.—We must constantly keep before us the contingency of any compartment in the ship being flooded either through collision or a submarine explosion in war time, when the whole circuit in that compartment would be short-circuited, and it is impossible to over-estimate the fuel that would be

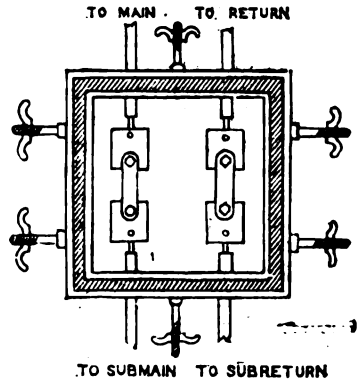

FIG. 2.—Watertight Cut-Out Box, with top removed.

added to the tendency to panic and confusion resulting from the "hurling" explosion of a torpedo or the crash of a collision, if they were followed by an extinction of light. Men can probably be trained to stand at their stations after the shock of some unknown accident; but to the listing ship and rush of water add darkness, the result can well be imagined. It is useless to talk of having the fighting candles always lit. These undoubtedly would be useful some ten minutes or so after the electric light had gone out; but shining through their small bulls-eyes after the glare of the electric light they would relatively produce but sufficient light to make the darkness visible. It is for reasons such as these that a proper method of connecting sub-mains in watertight compartments should be strongly insisted on, so that as far as possible the extinction of light may be confined to that one compartment. To do the first, the mains should be run the whole length of the compartments to be lighted, a submain being forked into each; secondly, a watertight cut-out box should be fitted near the fork in the submain, and all leads to that compartment taken away from the further side of this box. Such an arrangement would act as a disconnecter, and insulate the mains from the flooded area around. A rough sketch of such a box is given in Fig. 2. Of course, it is quite possible only one cut-out would go, in which case the other wire would put the dynamo to earth, which, for many reasons, is objectionable; but should it be thought necessary to arrange for the fusing of both, methods will occur to any mechanic or electrician

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of causing both cut-outs to go on the fusion of one. One more practical point in connection with this subject. Any person accustomed to cut-outs knows that often it is impossible to predict which of several cut-outs in series will go first; sometimes a short-circuit in a branch may cause the main cut-out to go, another time a sub-main, and perhaps a third time both—it is entirely a question of additional heating and of contact in the cut-outs. To save main cut-outs as much as possible, the mains should be large for the current they carry, their cut-outs as large as possible consistent with their fusing before the mains heat dangerously, and their contacts kept scrupulously clean; more than this cannot be done.

In placing cut-outs much of their efficiency depends on the positions chosen for them. Of course, in all circuits so liable to earths as those on board ship cut-out wires should be in the lead, and return wires of mains, sub-mains, branches, and in leads for single lamps as near the place of branching as possible. A single cut-out cannot guard against an earth leak in the opposite wire; it is therefore very necessary to have one in each. Cut-out blocks should not, if it is possible to avoid it, be placed under steam or water service pipes, or if they have to be placed there, they should be made thoroughly watertight, since the condensation of moisture due to varying temperature is often considerable. The wooden backs of switches or cut-outs, as well as brackets, should be filled in, where the wires lead through them, with an insulating cement, otherwise, with a sweating bulkhead, the horizontal holes become receptacles for the dripping water, and corrosion of the contacts, and earth leaks ensue. It is also a great help to sweat the lighting wires into the cut-out block, thereby reducing the number of surface contacts and the heating. If the man who wires a ship knows his work, he will place the switches and cut-outs in places where they are reasonably getatable, not, as is only too often done, some 10ft. overhead on the underneath side of the deck above, or high up out of reach on a vertical bulkhead. As may well be imagined, it is an exasperating thing replacing such cut-outs with the ship rolling. On such occasions a screwdriver, kept in the mouth, will prevent the active use of emphatic epithets. Whenever a cut-out is placed in the lead, and another in the return (as always should be the case), one should be a switch cut-out; if this is done it often means a great saving of time to the person replacing the cut-out, as he can at once switch off the circuit and replace the wires, otherwise he would be obliged either to switch off the whole circuit, or every individual light beyond.

Laying the Wires.—On board ship a favourite method of laying wires used to be to bed them in putty in wood casings, this, if carefully done, was often a very successful way; but if, as often was the case, the wire was put in first, and then putty pressed in on top, it was worse than useless, for the putty never fairly surrounded the wire, and there was invariably a space behind, not only for the wet to creep along, but to lodge and collect, and this, of course, put the first faulty place to earth, or in the case of a leak in each wire connected the two. In vertical casings the ends should be made watertight. Leaks are often traced either to water in a vertical casing, or to water which has come down such a downtake, and lodged in a horizontal casing. This especially applies to places where pipes form the continuation of a wooden casing. Junctions or forks in insulated wires cannot be made with too much care. It is perfectly useless using wire of high insulation if the forks in it are carelessly made, especially as the forks in the main and return are often close together inside the same casing, and therefore particularly disadvantageous for "non-contact" if carelessly made. With lead-covered wires of course casings can be totally dispensed with, except occasionally as "Scotchmen" in exposed places, clips and brackets of brass being used in lieu, consequently there is but little danger of water lying about the junctions in the wire. The junctions, however, in the class of wire should be most carefully made (and they require a little skill in making neatly), for the insulation or rather packing between the wire and the lead case is not watertight, and, therefore, any water inside the lead puts the conductor at once to earth. For really trying places, where the wires are exposed both to heat and wet, if carefully put up, this class of wire is invaluable. Whenever wires pass through watertight bulkheads, or any deck, watertight glands should be used to preserve the integrity of the bulkhead, otherwise, in time, if this is not scrupulously adhered to, the bulkheads become honeycombed and rendered perfectly useless.

Light Fittings.—It is a difficult matter to light a ship well, on account of the small height between decks. The officers' and men's quarters present but few difficulties, but the gangways or passages fore and aft the decks are different. These are the very places where overhead light is wanted, and yet cannot be placed for fear of damage to the fittings. All side lighting with bulkhead lights must necessarily be about the height of the eyes; consequently, if at the end of a passage these tend rather to blind one than to show the way. The only thing to do is to make the best of the circumstances, and light from the side if overhead lighting is unpracticable. Great care is required in selecting the places for lamps to be quite certain they are not "in the way." "Overhead" in a modern ship is a mass of hooks and brackets for the stowage of spare or handy gear; every hook and bolt has its meaning and use, which may interfere with a light in its close proximity. Careful selection for the position of fixings means great saving in repairs and broken glass afterwards. Another important point to consider about lamp fittings is suitable methods to prevent the injury to glass from the shock and concussion of guns. I say shock and concussion, because the damage is twofold, and may be communicated either by shock through the ship or directly by the concussion of the air. There is much still to be done in this direction, and at present the safest way is to unship the shades and often the lamps. The position of greatest danger of damage is that where the fitting is exposed directly to the concussion of the air, and is, therefore, above rather than on the gun deck.

Wandering Leads.—These are a nuisance wherever fitted, unless treated with care. Their chief place is in store rooms, as well as the engine and boiler rooms. Here they last but a short time. Oil, heat, and rough usage from people who have not their refitting, soon shortens their life. The plugs for their connection are a source of weakness. Flat spring contacts should be avoided in them if possible, for heating soon takes the temper out of the metal, and worse heating and fusing ensue.

Lanterns.—The prevalent idea is that any lantern will do to shade an incandescent light, or that any lens will suit it. The consequence is that the lanterns for incandescent lights are merely copies of those used for oil lamps. What really is wanted is merely a protective covering of metal and glass, as light as possible, with as large an aperture as may be required for the class of work it is to be used for, the protective covering to be only such a size as to prevent the glass being heated by radiation sufficiently to endanger it when brought in contact with cold or wet. As regards the use of a lens, it is doubtful if any would be of much good for the long filament of an incandescent lamp, and whether the extra expense and weight entailed would be repaid by an increase in range of visibility. The more ventilated such a lantern, consistent with actually keeping out water, the better. If bottom loops are used in the lamp they should be soldered to the hooks and the base filled in with putty. No trouble from damp or bad contact need then be feared.

Accumulators.—A few words about accumulators. If properly managed they are most useful auxiliaries to incandescent lighting. They are subject to no special ailments from living on board ship. The rolling of a ship affects the level of the liquid but little; and provided the containing vessel is built up some inches higher than the plates, no portion of them need ever be uncovered. They have been used in a ship rolling 36deg. each way without any trouble whatever. The most awkward part was the ventilation of the battery room, which was often not so good as might be wished; but after the first couple of months the discomfort of entering the room, when the cells were fully charged and charging, was not great, although the cells occupied about one quarter of the total cubic capacity of the room, which was below the water. The effect on the surrounding iron of the acid carried off with the gas was inappreciable. The containing vessels for service afloat are usually made of a form

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of hardened lead, thus are less liable to damage through concussion than if made of glass. The drawback, of course, is that the plates cannot be seen without lifting them out of the liquid, but one soon gets fairly expert at finding out any ailment, and its cause, without ever consulting the appearance of the plate. A thin strip of ebonite passed every week between the plates detects and removes any pellet that may have lodged between them. Should a cell fall in specific gravity and E.M.F., it is probably due to sulphating, and by reversing it in discharge and letting the discharging current charge it up (thus in charge or discharge it is always charging) their hearts, *i.e.*, the sulphate, will be broken, and they will come up. One must be careful at the same time to see that the temperature of the cell does not rise much. By carefully watching variations in specific gravity or E.M.F., or both together, and keeping the plates apart, it will rarely be found necessary to unbuild the cells to look at the plates.

Arc Lighting.—Arc lighting is dying out on board ship for lighting purposes. It never was much liked, being too brilliant for small areas. For search lights it is, of course, largely used, it being perfectly simple to keep an absolutely steady light for an hour or more together, worked as they are, by hand, with close attention, and, above all, much practice.

Testing Circuits.—It should be the aim of every one in charge of a circuit to prevent as far as possible any breakdown, however small. This can only be done by keeping the circuits free of faults, and the cut-outs, &c., clean. If once a circuit gets into bad repair it is a great labour to detect and correct *all* the leaks. It is only, therefore, by detecting and correcting

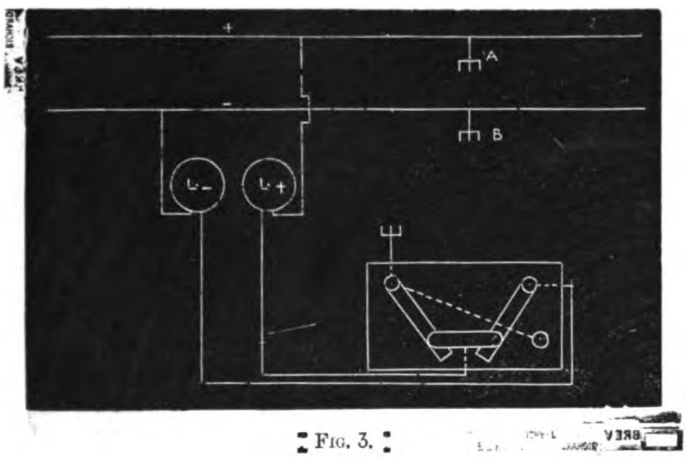

Fig. 3.

each leak as it forms that a circuit, with such an enormous adjacent earth as one on board ship has, can be kept in an efficient condition. Taking the ordinary insulated wire run in casings, the leaks that arise are twofold, leaks to earth and away to another leak and back to the machine, and two leaks adjacent in the casing never reaching the iron of the ship. Earth leaks can always be detected forming, or after they are formed, by the use of "earth lamps." Although the principle involved is simple, and the device old, the writer has met so few people who appreciated the use of these lamps, that he is tempted, at the risk of simply repeating what is well known, to dwell on the use and fitting of these lamps.

Two lamps, L+, L−, Fig. 3, of the voltage used in the circuit, are placed close together. A wire runs from L+ to the positive wire of the circuit, and one from L− to the negative; the other wires from these two lamps are taken to a switch, as shown, which is capable of doing the following things:—(1) putting both lamps in series; (2) putting the junction of the two lamps to earth; (3) putting each of the lamps separately to earth.

Now, suppose the right-hand bar moved to the left, both lamps will be burning in series, and will burn with roughly equal intensities, but, of course, at a greatly reduced candle-power. Now, by a motion of the left hand bar to the right, the junction of these two lamps will be put to earth. If there is no leak in the circuit, the relative brilliancy of the lamps will not be altered; but suppose a leak in the positive wire at A, it is evident that L+ and A will be in parallel, consequently more current will pass through L− than L+, and the lamps will burn with different brilliancies dependent on the size of the leak at A. Consequently these lamps show not only which wire the leak is in, but approximately the size of the leak, whether it is increasing or not; and often a good idea of the position of the leak may be formed, by its variation in wet weather—its intermittance, if in a portable connection—or its disappearance or alteration on switching on or off circuits. It is necessary on discovering a leak to put each of the lamps to earth to see that there is not a leak in both wires, otherwise the estimation of the size of the leak may be erroneous.

A peculiar case arises in Fig. 4, where A and B are the earth lamps, S a switch, and E an earth. While S is switched on, B will burn brighter than A, but with S to off the reverse will be the case, so that often a leak may be traced on a circuit being switched on or off in this manner.

It is not, however, in detecting the position of the leak that the chief value of these lamps lies, but rather in at once telling of the formation of a leak. To find the leak the simplest way is at some convenient time, probably during the night, to walk round with a lamp with two short leads of wire, start at the main switch-board, burn the lamp to earth, break each circuit for a second, and see in which circuit the leak lies; then follow it up by breaking the main circuit at each cut-out of the various sub-mains or branches till at last the branch with the leak is discovered; by this means leak after leak may be detected without the current ever being off a lamp except for a few seconds at a time. It is wonderful how cunning, after a time, men get in the use of these earth lamps, and are able to very shortly put their hands on a leak. Such lamps show a leak in the circuit of about 2,000 ohms.

As to the other class of leaks, which we might call "non contact," or double leaks to damp in the same casing, yet not to the earth of the ship, the writer knows of no method of discovering these except by keeping a careful look-out for signs of damp near a casing. The same old tale occurs time after time. A break in the circuit, or a casing heats; on taking the cover off the casing and removing the putty, that well-known green powder comes into view, the wire is removed, and found at the break as fine as a needle point, the insulation charred

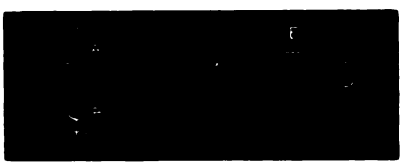

Fig. 4.

by the heating of the fine wire. The writer has a piece of wire before him with three breaks in the main and three in the return within a length of 4ft. The end of a vertical casing was not filled in, and the putty badly put in. One thing about these leaks. If in a case of this sort a break is found in a wire through this action, and there is no leak to earth, examine the other wire, and find the fault in the insulation that must exist, otherwise half the work is only done, and the whole casing will soon have to come down again.

The writer may have appeared to harp on leaks and cut-outs to an unwarrantable extent. He can only say that on board ship, with an installation of about 500 lights or so, and some 1,200 switches and cut-outs, iron and wet everywhere, to say nothing of carelessness and ignorance, the detection and repairing of leaks becomes part of one's daily duty; and there is no more pleasing sight with which to assure yourself that your staff are doing their work than your earth lamps burning with equal brilliancy.

The Telegraph in China.—China at present possesses no less than 16,488 English miles of telegraph wires, and the system is being constantly extended. The Government is now laying a line for more than a thousand miles, west to Kansuh, in order that it may be kept fully informed of Russian movements in the north-west.

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ON THE SPECIFIC RESISTANCE OF COPPER.*

BY T. C. FITZPATRICK.

All the values given in tables for the specific resistance of the metals are directly or indirectly obtained from the values given by Matthiessen in his series of Papers published in the *Transactions* of the Royal Society for the years 1860-64, and in the reports of the British Association for the same years.

In the *Transactions* † for the year 1860 is a Paper by Matthiessen, on the conductivity of pure copper and on the effects of impurities. No alloy of copper has so high a conductivity as the pure metal. His results are expressed in terms of the conductivity of a hard-drawn silver wire (100 at 0deg.). He gives the following values for samples of copper carefully prepared by himself:—

(1)	93·00 at 18·6°	Giving a mean value of 93·08 at 18·9° as the conductivity of pure copper.
(2)	93·46 „ 20·2°	
(3)	93·02 „ 18·4°	
(4)	92·76 „ 19·3°	
(5)	92·99 „ 17·5°	

Numbers are given showing the effect of small quantities of oxide on the conductivity, and he states that he found it necessary to pass hydrogen through the molten metal for some time for entire reduction. In the *Transactions* for 1862, Dr. Matthiessen had a Paper on the influence of temperature on the conductivity of metals. He again expresses his results in terms of a hard-drawn silver wire. On page 8 will be found the results of his experiments on copper; the lowest temperature at which measurements were made was 12deg. or 16deg.; he there shows how the results for pure copper measured at 18deg. may be reduced to 0°C.; but no measurement was actully made at 0deg. for any of the metals experimented with. He expresses the influence of temperature on a hard-drawn copper wire; the mean result of a number of determinations by the equation

$$\lambda = 100 - \cdot38701\, t + \cdot0009009\, t^2$$

where 100 is the conductivity of copper at 0°C., so that a hard-drawn silver and copper wire have the same conductivity at 0°C.

The values obtained by comparison with a hard-drawn silver wire are then largely the source of the tables of specific resistances; but at the end of his appendix to the Report of the Electrical Standards Committee for 1864 Matthiessen gives values for hard-drawn silver and copper wires in terms of the new B.A. unit, expressed as the resistance of a wire one metre long, weighing one gramme.

These values are:—

Copper	·1469
Silver	·1682

The same table of values is given in the *Philosophical Magazine* for 1865, where also is given a table of specific resistances for wires one metre long and one millimetre diameter expressed in terms of the B.A. units, calculated from the value of the known conducting power of the gold-silver alloy in terms of hard-drawn silver, and also in terms of the B.A. unit.

The values thus obtained do not agree at all well with the results calculated for the resistances of the gramme metre by the specific gravities of the elements furnished by tables.

Thus:—

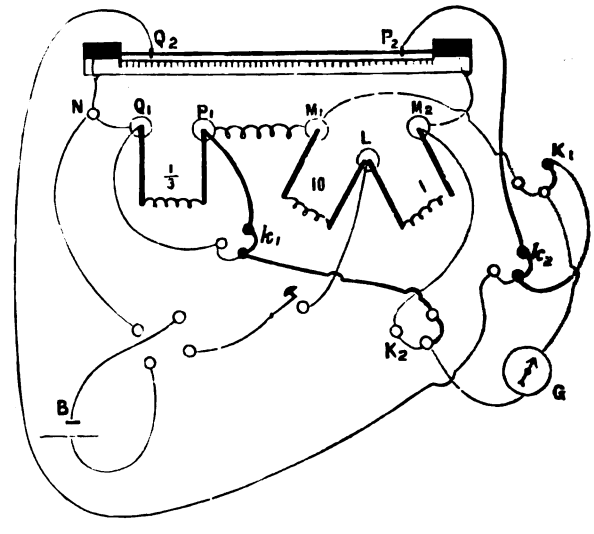
Silver	·02048		·02603
Copper	·02090		·02104

He states that he omitted to determine the specific gravity of the copper used in his experiments; he probably would not have obtained any very adequate results, and the weight of copper he used varied from 1·5 to 4 grammes.

The accuracy of Matthiessen's results seems to depend, therefore, on the accuracy of his determination of the resistance in terms of the B.A. unit of a hard-drawn silver wire; in considering, therefore, the question of the preparation of samples of copper of higher conductivities than Matthiessen obtained, it may be suggested that the cause of the difference is not the fact that Matthiessen did not prepare pure copper, but by the error in the value of the standard with which the comparison was made. I have, therefore, made a series of experiments on the resistance of pure silver wires, and, as a general result, have obtained a value identical with that of Matthiessen; the difference is not due, therefore, to an error in the standard employed, as far as my experiments go.

Matthiessen does not give anywhere the details of his measurements of the specific resistances of the metals in terms of the B.A. unit; in the B.A. report he simply mentions that an approximate table is subjoined, not even stating the fact that the values are for a temperature of 0°C. I conclude, therefore, that these values are calculated out from the former, of which an account is given in the same B.A. report, and which were performed at a temperature of 20°C. I have, therefore, in this account, as well as for other reasons stated later, made my measurements at the temperature of the air, and believe that as his values were reduced by a temperature coefficient to values at 0°C.; I shall, by using the same temperature coefficient, and raising his value to near that for 20°C., obtain results directly comparable with Matthiessen's direct measurements.

For the measurement of the resistance of the specimens of wire a Wheatstone's bridge arrangement was employed, two of the arms of the bridge were formed by a 10 and 1 standard B.A. unit, namely (66 and G); these were so nearly 10 to 1 that they were taken to be in that ratio. The third arm was one-third of a B.A. unit, and in the fourth arm was the wire to



be measured, this was stretched on a flat board, and soldered at the ends to copper plates, to which connecting wires were also soldered; the length of wire used was generally a little less than two metres, and the wires were, approximately, No. 18 B.W.G. The board had scales screwed to it at the two ends; the board and wire were placed in a long bath made of zinc, and filled with paraffin; wires which were left in the bath for some days, and, in more than one case, several weeks, were not found to have been at all acted on by the oil. One end of the wire, P_2, Q_2, was connected by a binding screw through an adjustable resistance, r, ($\frac{1}{2}$ metre of copper wire) to the mercury cup, Q_1, in which was one of the legs of the one-third coil, and also to a reversing key in the battery circuit. The one-third and the 10 were connected up together through an adjustable resistance, P_1, M_1, one leg of each of the coils 10 and 1 were in the same mercury cup, L; and the other end of the 1 B.A. unit was connected with the other end of the wire, P_2, Q_2.

A single Leclanché cell was connected up with the reversing key and the fourth point of this key was connected with the mercury cup, L, into which the legs of 10 and 1 dipped. In this circuit there was also a touch key. The galvanometer circuit was always made, and thus there was no thermo-electric effect on making the galvanometer circuit. To each of the mercury cups, Q_1, P_1, M_1, M_2, were connected with separate binding screws two thick wires, one of which was welded to the copper plate at the bottom of the mercury cup. Each of these latter wires were connected with two way-keys; those in P_1 and

* Paper read before the British Association in Section A, Leeds, September, 1890, being an Appendix to the Report of the Committee on Electrical Standards.

† *Phil. Trans.*, 1860, p. 85.

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Q_1, to the key, k_1; those in M_1 to the key, K_1; those in M_2 to the key, K_2.

The base points of the keys, K_1 and K_2, were connected with a delicate reflecting galvanometer, that employed for the comparison of the standards on the Fleming bridge. The base of the key, k_1, was connected with the third point on the key K_2, and the third point, on the key, K_1, was connected to the base point of a fourth key, k_2, the two other points on this key being connected with riders, with which contact can be made with two points on the wire, P_2, Q_2; the riders had straight edges, and thus their positions on the scale could be easily determined. In performing an experiment, the keys, K_1 K_2, were so connected that the mercury cups, and the ends of the coils, 10 and 1, were in circuit with the galvanometer. The resistance, R—P_1, M_1—was then varied till, on making the battery circuit, no deflection resulted. The ends of the 10 and 1 were then at the same potential, and as the other ends of these coils were connected with the same pole of the battery, there was the same fall of potential on the two lines. The keys, K_1 and K_2, were then reversed, and by the keys, k_1 and k_2, one end of one-third coil and one point on the wire, P_2 Q_2, were connected through the galvanometer, and afterwards the two other ends. The riders were adjusted till there was no deflection of the galvanometer. The length of wire between the two riders had a resistance of one-tenth that of the one-third B.A. unit coil.

By means of the series of keys it was easy to repeat the observations and to connect the ends of one-third coil with the wire. The resistance R did not often change during the experiments, as the room was at a constant temperature, any change in R only caused a shifting of the position of the riders. In each experiment, after all the adjustments, the bath was well stirred, and everything left for half-an-hour. It was generally found that the riders did not require any adjustment. The battery was reversed and all the coils moved. The latter never caused any effect; sometimes the reversal of the battery caus d a shifting of the two riders a millimetre or two in the same direction.

Another reading was taken three or four hours after. The coils one-third, 10, and 1, were in water baths, and their temperature remained the same for hours together. The temperature of the paraffin bath, of course, was not so constant, it was kept well stirred and a thermometer reading to ·2°C. never showed any difference in the temperature at the different ends of the bath when the readings were taken. The thermometer employed was Kew corrected; and the corrections given were verified by recent comparisonwith a platinum thermometer by Mr. Griffiths.

Since the two standard coils employed were accurately in the ratio of 10 to 1, the accuracy of the resistance measurement depended entirely on the value of the one-third B.A. unit. This was first made as nearly as possible one-third, but it was found that for the size of the wires measured (18 B.W.G.) this was too high a resistance; it had, therefore, to be reduced. For the determination of its value, there was cut out in a block of paraffin wax a large central mercury cup, and outside this a circular channel; thick copper plates were cut to fit them, and both were well amalgamated. By means of this cup arrange ment, the three B.A. units (H, G, and Flat) were connected up in multiple arc, and by means of stout copper rods the multiple arc arrangement was connected with the mercury cups with the Fleming's bridge, and so compared with the one-third B.A. unit, the temperature of the one-third being given. The following observations were taken:—

July 12, 1889:—1/3, (18·4°) + 986·6 (b.w.d.) = M.A. + 24·6 (b.w.d.)
July 22, 1889:—1/3, (17·4°) + 986 (b.w.d.) = M.A. + 24·1 (b.w.d.)
Aug. 26, 1890:—1/3, (16·8°) + 986·1 (b.w.d.) = M.A. + 23·9 (b.w.d.)

where M.A. denotes the resistance of the multiple arc arrangement.

The value of a bridge wire division (b.w.d.) is ·0000498 B.A. units at 15deg., and the wire has a temperature co-efficient of ·00143.

It is evident from these series of values that the one-third has not changed in resistance during the period of the experiments.

This comparison, however, introduced a possible error as the temperature of the bridge wire at the time of experiment was not accurately known, and this is important when nearly the whole of the bridge wire is employed. To eliminate this possible error, the one-third was compared with four B.A. units in multiple arc. In this case a large number of bridge wire divisions had to be subtracted from the value of the one-third, and the whole number of bridge wire divisions entering into the calculation for the values of the one-third was largely reduced. The four coils in multiple arc were (F, G, H, and Flat):—

Aug. 25, 1890:—1/3, 16·8° + 157 (b.w.d.) = M.A. + 852·05 (b.w.d.)
Aug. 26, 1890:—1/3, 16·8° + 157·5 (b.w.d.) = M.A. + 851·9 (b.w.d.)

All the four coils were at the same temperature (16·8). These values are taken from the B.A. Report, 1888.

Flat	1·000448
F.	1·000028
G.	·99955
H.	·99969

These give for the two multiple arc arrangements the values ·33330 and ·24998. The connecting rods had a resistance of ·00042, and hence the value of the one-third at 16·8° is found to be ·28537. The temperature coeffieient for the coil is ·0001 per 1°C.

To measure the lengths of the wires, two microscopes with scales and verniers reading to ·1 of a millimetre were set up and firmly clamped in position; the distance between them was determined by means of the beam compass with the aid of a third microscope; the distance between this and the other two being directly read off on the beam compass for set positions of the verniers. The wires were cut with a fine fret saw at the points corresponding to the position of the riders in the resistance measurements. Before weighing the wires were carefully cleaned with methylated spirits, the balance employed was the one used by Mr. Glazebrook for our determination of the specific resistance of mercury, the weights were balanced against one another, and in all cases double weighings were taken.

The specific gravity of most of the wires was measured, for this purpose distilled water was boiled and cooled rapidly, the coil of wire immersed and the beaker and its contents placed under the receiver of an air pump, which was connected up with a water pump, this was left running for two or three hours till all air bubbles had disappeared, the weight of the wire in water was determined, and a second reading taken some hours later; as the weight of wire used was from 16 to 20 grammes, fairly accurate values for the specific gravity of the several wires ought to have been obtained, and thus the value for each wire in terms of the B.A. unit for the resistance to conduction between the opposite faces of a cube of the material was found.

The first object of these experiments was to test directly in comparison with the B.A. standards samples of copper wire of high conductivities, with the view of comparing them with Matthiessen's standard. Application was therefore made to several firms for high conductivity copper wires; my thanks are due to those who sent samples.

A table of results is subjoined, the results for all the specimens tested are given, and they show the variation in resistance of high conductivity wires.

IV. and IV¹. are the same copper, but IV. is hard drawn, IV¹. is annealed; they were measured just as they were sent from the manufacturers; the same is true of V. and V¹., VI. and VI¹.

It will be noticed that VI. and VI¹., which are of considerably less resistance than the other wires, are of higher specific gravity; the firm that sent them thus wrote of them, "it is only occasionally we come across copper as high as this or high enough to be called the highest (in conductivity) we can produce. This copper has been produced electrolytically by our ordinary process." How this copper was treated after electrodeposition I do not know, I am inclined to think from my own experience that this difference in density is due rather to the condition of the copper, than to its relative purity. Matthiessen found that very small quantities of impurities reduced the conductivity 20 or 30 per cent. and a sufficient amount of impurities to cause a decrease in density from 8·94 to 8·90 would therefore make a larger increase in the resistance of the copper than is shown in the case of VI. and VI¹.

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The temperature coefficient is stated to be different for various specimens of metal, according to their purity; Matthiessen himself seems to have been of this opinion, but the mere difference in density of the metal might be expected to affect the alteration of conductivity for a given change in temperature.

I have not been able to find any experiments bearing on this question. It is quite easy to obtain samples of wire of different density by varying the process of drawing, and the temperature coefficients of such wires might be found to be different.

Comparing V. and V^1. with VI. and VI^1. it is seen that with this increase of density there is a distinct diminution in the effect of annealing.

IV. - IV^1. = ·00677
V. - V^1. = ·00577
VI. - VI^1. = ·00400

I thought it might be possible that VI^1. was not completely annealed, so for a direct comparison, two specimens of VI., which had been measured hard drawn on July 10 and 14, 1890, were annealed; for this purpose a flat copper vessel was made of about 2cm. height and 18cm. diameter, with a closely-fitting lid; the wire was packed in this between sheet asbestos, which had been previously heated up; the vessel was filled up with lampblack and heated over a big Bunsen burner; it was then gradually cooled; the process generally took about 24 hours; the wire was found not to be oxidised at all after the process was over.

Wire.	Hard-drawn.	Annealed.	Difference.
I.	1549	1510	·0039
II.	1548	1509	·0039

The difference Matthiessen obtained was ·0038.

The above method of annealing was found very effective. Silver wires, which on annealing decrease 10 per cent. in resistance, gave the same value in a second annealing as they did on the first occasion.

Wire VII. was a wire sent me by Mr. H. A. Taylor, and had to be drawn down before it could be measured; another piece of the same wire drawn down on a different occasion, gave the same value; this wire has the lowest resistance of any I have obtained; it has, too, the highest specific gravity. Mr. Taylor says of it, "That it has a higher temperature coefficient than that given by Matthiessen."

VIII. was a sample of wire obtained from Germany, and said to be electrolytically prepared; its high resistance is, I think, due to the presence of oxide, and I fused some of it up in hydrogen, and when measured partially annealed it gave the value 1566 at 18°C. for the wire 1 metre weighing 1 gramme, thus showing a very marked reduction.

IX., X. and XI. are wires of my own preparation. Pure copper was prepared electrolytically by Messrs. Sutton, of Norwich, and supplied me in thin sheet, and this was fused down in porcelain tubes of 18 centimetres in length and one centimetre in diameter; the tube was fitted up in a small furnace made of sheet iron and lined with ganister; this was heated readily by a blast flame led in at the bottom. Some difficulty was experienced in obtaining the copper in a solid cylinder; in the early experiments hydrogen was passed into the tube whilst the copper was being fused and was made to bubble through the molten copper; on breaking the tube, the copper was found to be full of small holes; the copper had absorbed the hydrogen at the high temperature and given it off again on cooling; on another occasion the copper was fused down in hydrogen and the tube was connected with a water pump and exhausted, and the copper allowed to cool in a vacuum; this gave a more continuous cylinder. It was found best to fuse the copper under borax, it having been previously reduced; a good cylinder of the metal was thus obtained.

I was unfortunately not able to draw down the copper for myself; this was very kindly done for me by Messrs. Smith, of Halifax, and Messrs. Johnson and Matthey. The porcelain tubes had been prepared of such a size that the cylinder of copper could be drawn without further heating; the copper, therefore, was not fused after it left my hands. Two sheets of the electrolytically prepared copper were fused down on different days, and one was sent to Messrs. Smith to be drawn, and the other to Messrs. Johnson and Matthey. Wires IX. were drawn by Messrs. Smith, wires X. by Messrs. Johnson and Matthey.

Wire XI. was drawn by Messrs. Johnson and Matthey from a sample of copper which I prepared by electrolysis, from a pure solution of copper sulphate; the copper was deposited on a plate of copper, which had had its surface rubbed over with graphite; by this means the deposited copper was easily stripped off the plate, the other plate was of platinum, after a time the solution was changed; the deposition was very slow, as it was thought that there would be less likelihood of copper sulphate getting in between the layers of copper. The deposit was boiled with dilute sulphuric acid and then in water, and was afterwards fused down as above described. Wires IX. were measured as received, this accounts for the close agreement between the two determinations. Wires X. and XI. I had to draw down further to measure them on my bridge. Wires X. (2.) and XI. were drawn down with great care and not so much as X. (1).

Resistance of Various Specimens of Wire.

Wire.	Date.	Resistance of a wire such that 1 metre weighs 1 gramme at 18°C.		Specific gravity.	Specific resistance per cc. at 18°C.	
		Hard drawn	Annealed		Hard drawn	Annealed
I.	July 22, 89.	...	1549	8·85	...	1743
	Nov. 6, „	...	1550	8·87	...	1745
II.	July 22, „	...	1545	8·88	...	1741
	Dec. 2, „	...	1546	8·89	...	1742
III.	Dec. 3, „	...	1713	8·87	...	1922
IV.	July 10, „	1578	...	8·89	1776	...
	Aug. 1, „	1578	...	8·89	1776	...
IV^1.	Nov. 1, „	...	1511	8·885	...	1724
V.	July 31, „	1573	...	8·89	1770	...
	Oct. 30 „	1572	...	8·89	1770	...
V^1.	July 20, „	...	1526	8·89	...	1712
	Aug. 2, „	...	1526	8·89	...	1713
	Aug. 8, „	...	1527	8·89	...	1716
VI.	Aug. 10, „	1546	...	8·94	1730	...
	Oct. 18, „	1549	...	8·94	1732	...
	July 10, 90.	1549	...	8·94	1731	...
	July 14, „	1548	...	not observed	...	...
VI^1.	Aug. 8, 89.	...	1508	8·94	...	1688
	Oct. 11, „	...	1509	8·94	...	1688
VII.	Nov. 4, „	1543	...	8·946	1724	...
	July 15, 90.	1543	...	...	...	...
VIII.	Oct. 23, 89.	1700	...	8·95	1903	...
	Oct. 28, „	1703	...	...	...	...
IX.	Aug. 5, 90.	1572	...	8·90	1766	...
	Aug. 18, „	1572	...	8·90	1766	...
X.	Aug. 5, „	1573	..	8·91	1767	...
	Aug. 26, „	1569	...	8·92	1751	...
XI.	Aug. 27, „	1569	...	8·93	1750	...
Matthiessen's value reduced to 18°, using his own coefficient.		1571	...	not given	1766·6	As calculated by Fleming, Jenkin & Fitzpatrick.

Below is a table of the measurements made for the determination of their specific resistances:—

Wire.	Value of 1/3.	Temp.	Weight of wire.	Length of wire for determination of resistance.	Length cut and weighed	Resistance of gramme per metre.		Density.	Specific resistance.
IX. (1.)	·28547	17·9°	20·388	192·1	192·5	1574	18·3°	8·90	1766
„ (2.)	·28541	17·4°	20·153	192·4	190·45	1569	17·5°	8·90	1766
X. (1.)	·28550	18·2°	19·708	189·3	188·8	1577	18·6°	8·91	1767
„ (2.)	·28536	16·8°	20·252	192·39	192·34	1561	17·1	8·92	1751
XI.	·28535	16·7°	20·262	192·11	192·51	1563	17·2°	8·93	1760

These values reduced to a common temperature of 18deg. are:—

IX. (1)	·1572	
IX. (2)	·1572	Mean value
X. (1)	·1573	·1571
X. (2)	·1569	B.A. units.
XI.	·1569	

Thus ·1571 B.A. units is the resistance of a metre of hard-drawn copper wire at 18deg. weighing 1 gramme.

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Matthiessen in the B.A. Report* gives as the resistance of a gramme metre at 0deg. ·1469 B.A. units. I have calculated from this the value at 18deg., using the temperature coefficient that he gives in his Paper on the influence of temperature on the conducting power of metals. I have taken no account of the terms in t^2, as they practically cancel one another.

$$R.\ (\text{at } 18°) = R_0\ (1 + ·0038701\ t)$$
$$R.\ (18°) = ·1571.$$

This is the same value that I have obtained as the mean of my own observations.

All my observations were taken at the temperature of the room, and in the table above the values for the different wires are given at the observed temperature, and then all reduced to a common temperature of 18°C. Most observations of this character are taken at the temperature of 0°C., but on the whole it seemed more satisfactory to work at the temperature of the room. In the comparison of the B.A. units I have found that with a difference of temperature between coils which are connected by thick pieces of copper there is always conduction of heat, and it is impossible to tell accurately what is the real temperature of the coils.

My observations were made in the B.A. room at the Cavendish Laboratory, which has a north aspect, and often the temperature does not alter more than a few tenths of a degree, whilst the temperature of the coil baths often remains perfectly steady for several consecutive days. I cannot find any observations of Matthiessen's at 0°C; certainly his observations on copper were made at 18deg., and, consequently, if the value given by him at 0°C. has been obtained by the use of a temperature coefficient, my value might be expected to agree with his at 18deg., the temperature of his observation, supposing the samples of copper of the same character.

Matthiessen's results are given in terms of a gramme per metre, also for wires of metre length and 1 mm. in diameter. In his Paper in the *Philosophical Magazine* above referred to Matthiessen gives us the value for hard-drawn copper in these terms as,

·02104 B.A.

From his value for the gramme metre, using the specific gravity 8·95 given by tables, the same quantity was calculated but gave the result ·0209; in a note added, he states that had he used the specific gravity 8·91, his results would have been more nearly alike; a specific gravity 8·90, I find, would give an almost identical value.

This would show, then, that Matthiessen's own table calculated for values obtained by comparison with hard-drawn silver is accurate; I have tested silver wires, but have not had time to draw up the results in tabular form; and I obtained an almost identical value for hard-drawn silver wire, as supplied me from Messrs. Johnson and Matthey, as is given by Matthiessen for the resistance of a gramme per metre.

It will be observed that wires IX. have the specific gravity 8·90, and give a value in terms of B.A. units for a cubic centimetre of the material identical with Matthiessen's value; this value is not given directly by Matthiessen, but is calculated from his results by Fleming Jenkin, and given in his table in his book "Electricity and Magnetism," it is 1652. I have calculated it from Matthiessen's value given in the *Philosophical Magazine*, and get the number 1653. Using the same temperature coefficient as before, the resistance of a cubic centimetre of hard-drawn copper is 1766·6. On comparing the values for wires IX., X., and XI. in these terms, the results do not agree so well together as when expressed in terms of the gramme metre; there is a corresponding difference in the values of the specific gravities, these latter have been very carefully determined, repeated with the results given. Wires, therefore, of the same resistance expressed for grammes per metre may give a very different result, when expressed as per cubic centimetre; attention has been drawn to this fact in the discussion on the Elmore copper in *The Electrician*.† M. Roux, of Paris, in a letter gives the following table for high conductivity wire, from a paper of M. Hospitalier in *l'Electricien*, 1887; this paper I have, unfortunately, not been able to see.

Density	8·897	9 32	9·6
Conductivity equal volume	102·4	106·7	110·8
Conductivity equal weight	101·7	101·2	101·6

What is 100 in the conductivity units is not expressed. M. Roux thinks that the former is the more rational method of expressing the result, *i.e.*, for one of equal volume.

Matthiessen expressed all his results in terms of equal weight, justifying it by the greater accuracy obtainable when working with small weights of wires. Small errors in the value of the specific gravity are easily made, and cause a similar error in the result for equal volumes of different wires; unless working with long lengths of thick wire the weight of the wire is small, and the weight of the water displaced cannot be determined within ·5 to 1 milligramme, and that only with care; this error in ·5 of a gramme means only an accuracy of 1 in 500. The values given in my table are probably correct to 1 in 1,500 or 1 in 2,000, as the weight of water displaced was in all cases over 2 grammes. Results, therefore, for resistances of wires of equal weight are the most trustworthy, and, I think, also the most satisfactory if used to express the resistance of a material and not of any given wire.

Wires X. (1) and X. (2) are of the same copper, but drawn down separately; X. (1) was beginning to fray, and another specimen of the same copper drawn down still further had on this account to be rejected; this has effected the resistance value expressed in both ways. Thus

X. (1)	1573	.....	1767
X. (2)	1569	.....	1751

but much more so when expressed for equal volumes. In both the copper is of the same quality.

It will be noticed that with increase of specific gravity there is a decrease of resistance, even when the results are expressed for wires of equal weight; the resistance diminishes, therefore, more rapidly than the density increases. Wires, therefore, of the same quality may, in consequence of a difference in drawing, have a different density, and so the results expressed in terms of equal volume will differ considerably; while those for equal weight are the same, or approximately so.

The values obtained for IX., X. and XI. are so nearly identical that it is not unfair to conclude that they are samples of pure copper; their value is identical with that obtained by Matthiessen at, I believe, the same temperature. The greater difference obtained at 0°C. between Matthiessen's value and samples of copper tested now at that temperature, is probably due to the fact that Matthiessen's value was not determined at 0°, but reduced in value for that temperature from observations, as stated above, at about 20°C.

The higher conductivity or less resistance for the two samples given in the table is due not to increased purity in the preparation of the copper, but in the difference in the process of preparation, whereby a sample of greater density is obtained than results from the working up of small quantities of copper in the laboratory.

A sample of copper has been prepared by chemical means with the help of my friend, Mr. Skinner, but has not yet been measured.

Sparks from Belts.—An interesting note comes from a correspondent of the *Electrical World* in Woonsocket, R.I. Some time ago there was trouble with one of the arc machines in use, and after a careful investigation by the electrician, it was found that the static discharge from a belt to the frame, and thence to the armature, perforated the insulation so that the machine current had followed it and burned out the armature coil. The trouble once found, a very simple and effective remedy was employed. Grounded rods were bent from the pulleys so as to take the static discharge from the belt. It is well known that a powerful spark can be obtained from belts under certain circumstances, but this is a remarkable instance of its effect,

* B.A. Report, 1864.

† *Electrician*, December 7, 1888.

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DISTURBANCES ON TELEPHONE AND TELEGRAPH LINES.

The interference of inductive and stray currents on telephone and telegraph lines is a difficulty which has sufficiently asserted itself, but which is at present "nobody's business" to remedy. Vested interests are so often synonymous with selfish obstruction, and have in most cases to be fought by the interested minority in so unpleasant a fashion, that efforts to uphold them meet with little sympathy from the general public. We do not see at present how the difficulties which have already cropped up are to be most economically and equitably met; and it is somewhat doubtful if the metallic return which was pronounced to be an effectual cure by General WEBBER in the discussion, at Leeds, on the Lineff tramways, and which it was hinted would speedily be adopted by the telephone companies, will prove to be so complete as could be desired.

The paper by Dr. LOUIS BELL, of which an abstract will be found in another column, sufficiently indicates that a metallic return in a tramway system will not necessarily remove the evil, though it may be presumed that both the railway and the electrical authorities of the Board of Trade will take care that, as far as actual leakage is concerned, we shall have less cause for complaint than our American friends. But as far as the Board of Trade rules have gone at present the first consideration is the security of the public from shocks, and it was from this point of view, we believe, that the Northfleet line was passed by Major CARDEW. The Postmaster-General has a voice in the matter, and all regulations of the Board of Trade are submitted to his scientific adviser, who is fully alive to the difficulties which have already arisen in connection with Deptford and other experiments, and who has protected the postal telegraphic service, not only by means of these regulations, but by very general and comprehensive clauses in the Provisional Orders. The magnitude of a disturbance which would not appreciably effect an ordinary

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even a refined and delicate form of duplex telegraph line might have most serious effects on a telephone circuit, and every London subscriber is already aware that cross-talk and innumerable varieties of buzzing and humming even now seriously detract from the value of the telephone service in the metropolis.

The Post Office, having as yet done little else in telephony than to provide a pattern service in a single town, it cannot be expected that the regulations and clauses which have been drawn up for the protection of its lines will be used for the benefit either of the telephone companies or of their subscribers. If the telegraph lines of the Post Office are affected by induction from neighbouring circuits used for industrial purposes, or are disturbed by stray leakage currents, the effects, if objectionable, will also be measurable; and if measurable, there will be but little difficulty in determining the nature of the disturbance, and in detecting the exact cause. But buzzing on a telephone line may be sufficient to render conversation impossible, and yet the currents which produce it may be of an order of magnitude that would tax even the measuring powers of Mr. Vernon Boys. A simple case was discussed in our columns some time ago (see *The Electrician*, November 9, 1888), in which a distinct note of a more or less musical, but none the less undesirable character, was heard on a private city telephone line. Neither the line nor the instrument which caused the noise could be discovered for some time, since the only knowledge that could be obtained about it was the period of the vibration and the time of day at which it occurred. A buzz or hum in a telephone is generally the result of a minute current or succession of currents, which are otherwise utterly inappreciable, and there is no evidence to produce about such a nuisance than that, at a certain time of day, conversation between certain individuals by means of certain telephonic apparatus is rendered difficult or impossible. Such a nuisance would be considerably more difficult to prove than the obstruction of ancient lights or production of noxious vapours. Even the crowing of a cock has been held to be a nuisance, but the actual cock had an existence, and could be fully described in the indictment. A humming in a telephone is *vox et præterea nihil*. There is no doubt but that a noise which is highly objectionable to one person causes but a slight inconvenience to another, and without some measurement it will be difficult to say when a disturbance on a telephone circuit begins to become a nuisance.

The idea of the right to use the earth for a return circuit on account of prior use, thus constituting a vested interest, was not only set up but was seriously contested only a few months ago. The comprehensiveness of such a claim is rather difficult to conceive, and it is quite impossible to tell how such a notion will strike the legal mind in this country. The matter has come to the front so recently that we are at present without evidence as to the nature or degree to which these disturbances are likely to exist. The case described by Mr. Cuttriss, in which the cable of the Commercial Cable Company was affected by an electric railway running parallel to it, is probably an extreme one, although only one line was disturbed. The other cases mentioned by Dr. Louis Bell are not so formidable, and when further accounts of similar instances have been collected with numerical details, we shall be in a better position to judge whether our telephone systems are likely to be seriously affected by the growth of electric lighting and transmission of power, or whether such interference will be rare. A simple formula could be easily given on the basis of the factors given in Dr. Bell's Paper, omitting, however, the periodicity of the disturbing current, since this will affect the quality and pitch of the noise only if the alternations be sufficiently rapid to produce a musical note. But before we can use such a formula, it will be necessary for us to know more exactly than at present the magnitude of the currents which are audible in a telephone.

It might be advisable if only for the purpose in question, though the general importance is obvious, that we should have some further knowledge of the actual strength of telephonic currents. The experiments of Mr. Preece are almost our only source of information, and the method by which they were arrived at is open to several objections. We should have some easily reproducible micro-milli-ampere, or whatever else the word-coiners may call it; we might then perhaps balance these disturbances by a small measurable current of a similar period, and thus determine their value. From continuous current supply, whether with batteries or without, there is not much probability of disturbance. Electric lighting circuits can do no harm, motor circuits may have a slight effect if frequently switched on and off, and tramway lines, owing to imperfect contacts and the changes of position of the points of contact, have already given rise to very perceptible effects. For alternating current supply we fear a new difficulty is thus presented; but we are sure that the combination of science and good engineering will find a remedy for ordinary work, and it is to be hoped that accidental leaks will be as rare in the future as in the past, so as to make unnecessary any special precautions on this score. For the telegraphs we have nothing to say; they are fully protected by the Board of Trade and Provisional Order regulations. The only parties with whom we really sympathise are subscribers to telephone exchanges.

ON THE VALUES OF CERTAIN STANDARD RESISTANCE COILS.*

BY R. T. GLAZEBROOK, F.R.S.

The B.A. Unit Standards.

The Standard B.A. units of the Association have during the year been several times compared together both by the Secretary and by Mr. Fitzpatrick. Table I. gives the results of two sets of comparisons made in August, 1890. The differences between the various coils and the platinum silver standard Flat are given in the third column in bridge-wire divisions. One bridge-wire division is very nearly ·00005 B.A. unit.

Table I.—*Resistance of the B.A. Standards, August, 1890.*

Coil.	Temperature.	Difference between each coil and flat in bridge-wire divisions.		Observed calculated.	Change of resistance per 1°. C in b.w.d.
		Observed Aug. 15, 1890.	From chart 1888.		
A	17·2	27·8	33·0	- 5·2	28·6
B	17·4	30·5	30·5	0·0	28·8
C	17·6	22·2	23·0	- 0·8	14·2
D	17·25	61·2	63·5	- 2·3	61·7
E	17·3	79·2	79·5	- ·3	60·7
F	17·3	3·2	- 9·5	12·7	5·7
G	17·5	- 22·0	- 18·0	- 4·0	5·5
H	17·4	- 17·0	- 15·0	- 2·0	5·6
		August 19.			
A	18·8	67·5	69·5	- 2·0	28·6
B	17·8	60·6	62·0	- 1·4	28·8
C	19·2	31·6	36·0	4·4	14·2
D	18·8	145·7	15·1	5·3	61·7
E	19·0	170·6	17·3	2·4	60·7
F	18·9	2·9	- 9·5	12·4	5·7
G	19·0	- 21·8	- 18·0	- 3·8	5·5
H	19·0	- 17·7	- 15·0	- 2·7	5·6

* Paper read before the British Association in Section A, Leeds, September, 1890, being an Appendix to the Report of the Committee on Electrical Standards.

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In the fourth column are given the corresponding differences obtained from the chart made in 1888. In the next column will be found the differences between the observed values and those given by the chart, while the sixth column gives the change in resistance for 1° C. for the various coils. It will be seen that for the first five coils the differences between observation and the chart are such as would be readily accounted for by a small error in the temperature, and we may say that there is no evidence of a change in the resistance of these coils relative to Flat. This conclusion is borne out by the results of a series of observations made in January and February by Mr. Fitzpatrick. But when we come to the three platinum silver standards, F, G, H, the results are at once seen to be quite different. Thus F would appear to have risen relatively to Flat by about 12·5 bridge-wire divisions, while G and H have fallen by 4 and 2·5 divisions respectively.

Since these are the most important standards, their temperature coefficients being all very small, it was necessary to examine their history with some care. A change in F had been noted in a postscript to the Report for 1888. The general conclusions of that Report were that up to the summer of 1888 there had been no change in the value of the coils. It was shown that all the original platinum silver coils examined then—those of Messrs. Elliott, H. A. Taylor, and others, as well as those belonging to the Committee—had apparently fallen in value relatively to the mean B.A. unit by about ·0007 B.A.U. since 1867, but evidence was adduced to show that the fall was only apparent and was due to an error in the temperature coefficient used at that date. A single observation of Chrystal in 1876 pointed to the possibility of a change in F, but that change was not confirmed by other evidence; while so far as the platinum silver coils were concerned, the observations of Dr. Fleming in 1881, and myself in 1888, agreed closely.

Since 1888, however, changes have shown themselves.

These are evidenced by the three following tables II., III., and IV., which give the differences Flat-F, Flat-G, and Flat-H respectively.

Table II.—*Value of* Flat-F.

Date.	Temperature.	Value.
Chart 1888	10·0	10·5
	15·0	9·5
	20·0	8·5
May 16, 1888	14·8	9·0
July 2, „	0·0	3·0
July 3, „	14·8	3·8
July 13, „	14·2	4·2
July 13, „	14·6	3·3
July 14, „	14·7	3·3
July 28, „	16·7	4·2
Jan. 27, 1890	10·0	-4·0
May 31, „	14·4	-3·5
Aug. 15, „	16·9	-3·2
Aug. 29, „	16·7	-3·0

Table III.—*Value of* Flat-G.

Date	Temperature.	Value.
Chart 1888	10·0	17·5
	15·0	18·0
	20 0	18·5
July, 1888	14·6	16·6
Jan. 27, 1890	10·0	16·9
Jan. 29, „	4·5	16·7
Feb. 4, „	6·0	16·6
May 31, „	14·4	21·5
June 10, „	16·0	21·4
June 11, „	16·0	22·2
June 12, „	16·0	22·2
June 13, „	16·0	22·2
Aug. 9, „	19·0	21·8
Aug. 15, „	17·0	22·3
Aug. 29, „	16·5	22·6
Aug. 29, „	16·5	22·5

Table IV.—*Value of* Flat-H.

Date.	Temperature.	Value.
Chart 1888	10·0	15·5
	15·0	15·5
	20·0	15·5
July, 1888	14·6	14·1
Jan. 27, 1890	10·0	17·5
Jan. 29, „	4·5	17·5
Feb. 4, „	6·0	16·5
May 31, „	14·1	18·3
June 10, „	16·0	18·1
June 11, „	16·0	17·7
June 12, „	16·0	16·4
June 13, „	16·0	16·8
Aug. 9, „	19·0	17·7
Aug. 15, „	17·4	17·0
Aug. 28, „	17·0	17·8
Aug. 29, „	16·4	18·2

The three first lines in each table give the differences at the temperature shown taken from the chart drawn in 1888; the remaining lines give the differences actually observed, with the dates and temperatures. Thus, taking the various coils, it is clear that while up to May, 1888, the difference between Flat and F remained the same as shown by the chart and observations up to that date. A change took place during the low temperature observations in July, 1888, while by the time the coils were again examined in January, 1890, a further change had manifested itself. This continues up to the present date, so that now at temperature of about 15deg. the coil F has increased in resistance relatively to Flat by about 12·7 bridge-wire divisions. This, assuming the whole change to be in F, will correspond to a rise of resistance of ·00063 B.A. units, or in other words the temperature at which the coil is right has fallen by about 2°3. In January, 1890, the coils were again exposed to a low temperature, and it seems probable that the changes took place when the coils were in ice.

Turning now to Table III., which gives the values of Flat-G we see there is no evidence of change till May, 1890. The observations in July, 1888, and January and February, 1890, are quite in accordance with the chart, but in May, 1890, it is clear that G has fallen relative to Flat.

The value of the difference at a temperature of 16deg. is 22·1 b.w.d. as against 18·1 given by the chart. Thus G has fallen relatively to Flat by 4 b.w.d., or ·0002 B.A. units. This change was first observed after the coils had been exposed to a low temperature.

With regard to H the change first showed itself during the low temperature observations in January and February, 1890, and Table IV. indicates that the difference between Flat and H is now 17·5 divisions as against 15·5 in 1888, or in other words, that G has fallen by ·0001 B.A. unit. Also since Flat-F changed in 1888, while Flat-G and Flat-H did not, we infer that the change at that date was in F, not in Flat, while since Flat-H changed in January, 1890, without a change in Flat-G, it appears that the change was in H, not in Flat; and finally, from the observations in May, 1890, which show a change in Flat-G, but none in Flat-H and Flat-F, we infer a change in G.

As to the cause of these changes, we can say but little. We hope to investigate them more completely by the aid of the coils lent by Mr. H. A. Taylor and others, and referred to in the 1888 Report; but it seems possible that they are due to strains set up in the wire by the great contractions and expansions produced by cooling and heating in the paraffin in which the coils are embedded. The coil Flat is of a different shape to the others and little or no paraffin has been used in its construction. The other coils, F, G, H, are embedded in paraffin in the usual way. On cooling down to 0°, this shrinks greatly, and it is quite conceivable that this shrinkage may have strained the coils and so caused the change. We hope to test this by having coils made free from paraffin and investigating with them the effects of repeated heating and cooling. The fall of H and G would be accounted for by a loss of insulation causing a slight leak either from the wire to the case or across the surface of the paraffin. The insulation resistance for F, G, H, was therefore tested and found in each case to be several thousand megohms, while the surface of the paraffin, which had

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become dirty with time, was scraped, but without producing any change in the resistance. A leak, of course, would not produce the rise found in F.

Observations of the coils at 0° have always been unsatisfactory and attended with considerable difficulty. This is mainly due, I believe, to the fact that the temperature of the room in which the observations have been made has usually been above zero, and that heat is conducted into the coils by the thick copper connecting rods. It would seem possible, however, that part of the difficulty (*See* Report of the Committee for 1888, Table VII.) may have been due to real changes in the resistance arising from strains set up by the cooling.

The Legal Ohm Standards.

The results of observations on the legal ohm standards of the Association are given in the Report for 1886. Experiments made in these between July, 1884, and January, 1886, showed that while one coil, C.L.C. 100, had retained its value unchanged, the other, C.L.C. 101, had varied. These observations have been continued, and the results are given in the following tables, which give the value of each coil as found by direct comparison with the standard B.A. units, and its value as given by the chart in 1886.

Table V.—*Results for C.L.C. 100.*

Date.	Standard used in comparison.	Temperature.	Value.	Value on Chart.	Difference.
Feb., '87	F	16·3	1·00009	1·00008	·00001
Nov., '89	G	15·8	·99997	·99996	·00001
"	"	14·8	·99971	·99968	·00003
"	"	16·0	·99998	1·00000	·00002
Dec., '89	Flat	14·4	·99962	·99959	·00003
"	"	14·8	·99969	·99968	·00001
"	"	13·2	·99925	·99924	·00001
...	...	6·2	·99744	·99735	·00009
...	...	5·7	·99729	·99720	·00009

Table VI.—*Results for C.L.C. 101.*

Date.	Standard used in comparison.	Temperature.	Value found.	Value on chart in '85, '86	Difference.
Feb., '87	F	16·3	·99970	·99930	·00040
Nov., '89	G	15·9	·99955	·99920	·00035
"	"	15·1	·99932	·99899	·00033
"	"	16·0	·99955	·99922	·00033
Dec., '89	Flat	14·4	·99909	·99880	·00029
"	"	15·0	·99925	·99897	·00028
"	"	13·3	·99879	·99850	·00029
...	...	7·6	·99725	·99695	·00030
...	...	6·5	·99701	·99668	·00033

These tables show three facts conclusively: (1) That up to December, 1889, no appreciable change had taken place in the relative values of C.L.C. 100—the Legal Ohm Standard—and Flat or G; (2) that between January, 1886, and February, 1887, C.L.C. 101, which had varied previously, changed by about ·0004 ohms; and (3) that the greater part of that change has remained permanent up to December, 1889. At present the difference between C.L.C. 100 and C.L.C. 101 is about ·0004; in 1886, it was about ·0008. The agreement between the observations in November and December, 1889—in one set of which Flat was the standard of comparison, while in the other G was used—show that the relative change in G and Flat took place after this date.

A COMPARISON OF A PLATINUM THERMOMETER WITH SOME MERCURY THERMOMETERS AT LOW TEMPERATURES.*

BY E. H. GRIFFITHS, M.A.

The Paper describes the mode of constructing an air-tight platinum thermometer for use at low temperatures. The thermometer was graduated by means of the freezing and boiling points of water, and as regards intermediate points Regnault's determinations of the temperature and pressure of aqueous vapour were adopted. The curves, showing the result of comparison with a number of thermometers standardised at Kew, are in remarkably close agreement.

In a communication* to the Royal Society read on June 19, 1890, a method was described of constructing and graduating platinum thermometers and a table of boiling and freezing points for various substances lying between 100deg. and 500deg., determined by means of these instruments. I was unable to discover any suitable non-conductor capable of resisting high temperatures; but in anthracene (melting point 213deg.) I found a substance suitable in every respect for use at low temperatures. I subjected a sample to severe tests, and, up to a temperature of about 130deg., found it to be a better insulator than paraffin. The leads to the coil were constructed of silver, the inner one a rod and the outer a tube. The resistance of these leads was about ·001 ohm, and, therefore, any change in the external resistance, caused by change of temperature, might be disregarded. The wire forming the coil was about 56in. in length, and had a diameter of ·005in. The spiral was about 1½in. long, having a resistance of about 13·5 ohms at 0°C., and the external diameter of the covering tube was about ·3in. The ends of the asbestos roll were made of greater diameter than the portion on which the spiral was wound, and thus there was no glass contact. The tube and contents were heated up to a temperature of several hundred degrees, and dried air passed through it for some hours. It was then exhausted and the open end placed under the surface of melted anthracene, which was allowed to rise until nearly in contact with the coil. When cool, the whole of the thermometer, from the spiral to the upper end (about 13in.) was a solid mass, while the spiral and asbestos roll were perfectly dry and in an almost vacuous space. When the lower part was undergoing rapid changes in temperature, thermo-electric effects showed themselves, but by reversing the battery and galvanometer connections during each reading these effects were eliminated. A low-resistance galvanometer was used, and the current, which passed through the thermometer when determining its resistance, did not exceed one hundredth of an ampere.

The expression for the platinum temperature by this thermometer was

$$\frac{(R - 13{\cdot}5219)}{4{\cdot}6811} \times 100, \text{ again } \frac{R_{100}}{R_0} = 1{\cdot}3462,$$

almost exactly agreeing with the coefficient of the wire in Mr. Callendar's air thermometer (*Phil. Trans.* A 1887).

Mr. G. M. Clark now joined me, and as we proposed to use this thermometer for the calibration and graduation of mercury thermometers between 0deg. and 100deg., we decided to obtain intermediate temperatures by means of Regnault's numbers connecting the temperature and pressure of aqueous vapour.

The extremities of the curve at 0deg. and 100deg. having been determined, it was only necessary to get points between 30deg. and 80deg.

Ninety observations were taken, and although occasional divergences presented themselves, the mean path gives a curve which we believe to be within less than ·02deg. of the true path at all points. It agrees closely with the curve obtained by Mr. Callendar from the parabola $1{\cdot}57\left[\left(\frac{t}{100}\right)^2 - \frac{t}{100}\right]$, by measuring one-tenth of the ordinate along the abscissa.*

The following equation, however, represents its path more accurately.

$y = {\cdot}018795t - {\cdot}0001991t^2 \times {\cdot}000{,}000{,}111{\cdot}5t^3$; the curve itself is shown in Chart A.

The results of comparison with thermometers standardised at Kew show:—

1. That thermometers whose range does not include 0deg. and 100deg. may have certain fixed points determined by this method.

2. That an actual calibration of a mercury thermometer can also be readily accomplished.

* Abstract of Paper read before the British Association in Section A, Leeds, September, 1890, being an appendix to the Report of the Committee on Electrical Standards.

* It must be remembered that Callendar's difference curve gives the connection between platinum and air-thermometer temperatures, whilst Regnault used a mercury thermometer (M.A.S. XXI.), and thus curve A gives the relation between platinum and mercury thermometer temperatures.

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3. That the platinum thermometer, properly constructed, may serve as a standard by which to trace the changes which may take place in mercury thermometers.

4. That since the readings of the platinum thermometer are independent of the extent of the stem-immersion, it can be conveniently employed for the graduation of thermometers partially immersed, as in ordinary use.

We have calibrated about twenty thermometers by this method, and we believe the results to be satisfactory in all cases.

ON THE AIR CONDENSERS OF THE BRITISH ASSOCIATION.*

BY R. T. GLAZEBROOK (with a Note by Dr. A. MUIRHEAD).

The question of issuing certificates of capacity has from time to time been discussed by the committee. The following Paper gives an account of some experiments that have been in progress during the past two years with this object in view.

In the report for 1887 the committee express the opinion that it is desirable to proceed with the construction of an air condenser. In conformity with this opinion, a meeting was held in London, at which Dr. A. Muirhead exhibited an air condenser consisting of a series of concentric brass cylinders insulated by glass rods, which appeared to the committee to possess great merits; and it was decided that the secretary should test this and two similar condensers which Dr. Muirhead offered to lend, before proceeding further with the construction of condensers for the Association. The tests were carried out with satisfactory results.

The capacity of each condenser was determined repeatedly, using the method of a vibrating commutator, due to Maxwell, already employed by J. J. Thomson, *Phil. Trans.*, 1883, and Glazebrook, *Phil. Mag.*, August, 1884. The values found were :—

$$C_1 = \cdot0030514 \text{ microfarads.}$$
$$C_2 = \cdot0031258 \quad ,,$$
$$C_3 = \cdot0033288 \quad ,,$$

It was found that the capacities remain constant from day to day, and that the accuracy of a single determination was about 1 in 1,000, although the capacity to be measured was so small.

A mica condenser belonging to the Cavendish Laboratory was compared with these—details of the method will be given shortly—and it was found that when comparing a condenser of one microfarad with the three air condensers, having thus a combined capacity of ·009506 microfarads, so that the ratio of the two was about 100 to 1, an accuracy of about 1 in 1,000 was attained. It was also shown that the capacity of the mica condensers as thus found, differed by nearly 2 per cent. from its value as determined by the rapid commutator, thus proving that the commutator method was unsuitable for a condenser showing absorption.

Thus, for three mica condensers, the following values were found :—

With commutator.	By slow method of comparison.
·9690	·9868
·4934	·4994
·09543	·09644

These results make the necessity for an air standard all the more apparent. A report on the experiments, made up to that date, was laid before the committee at a meeting in London, in April, 1889. It was then decided to adopt Dr. Muirhead's form of condenser, and to have two made on the same pattern for the Association. These have been constructed by the Cambridge Scientific Instrument Company, following Dr. Muirhead's plan, but on an enlarged scale. Each has a capacity of about ·02 microfarads, or about six times that of one of the original condensers.

Fig. 1 shows the arrangement.

The condensers consist of 24 concentric tubes; the outer tube is about 2ft. 9in. high and 6in. in diameter. Each succeeding tube diminishes in diameter by half an inch; the tubes are about $\frac{1}{32}$nd of an inch in thickness, and the air space between the inside of one tube and the outside of the next is about $\frac{3}{32}$in., but it was found impossible to get all the tubes of exactly the same thickness, so that in some cases the distance between the tubes is less than the above. These tubes are carried by two conical brass castings; the outside surface of each casting forms a series of twelve steps, over which the successive tubes fit. Each

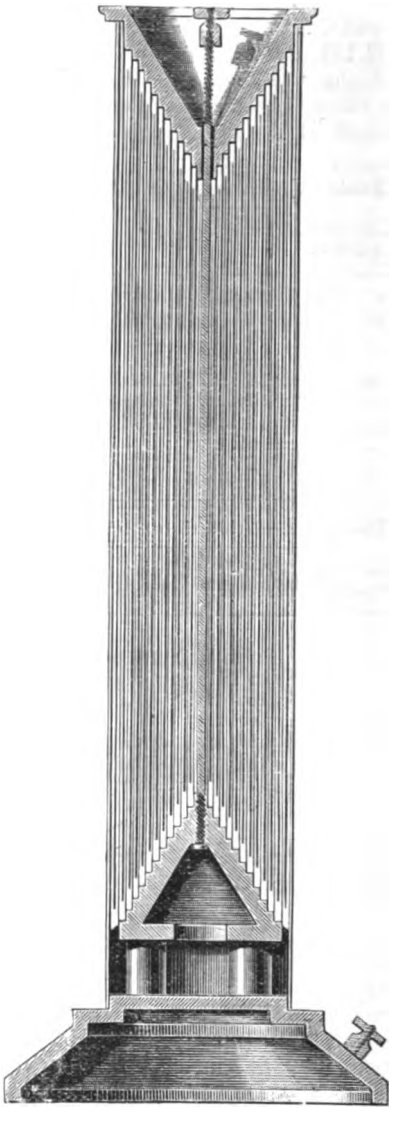

FIG. 1.—Section of a Muirhead Standard Air Condenser constructed by the Cambridge Scientific Instrument Company.

tube is held in position by screws. The upper cone is supported by the outside casing of the condenser, and twelve of the tubes hang vertically from it. The lower cone is carried by three ebonite pillars, about 3in. in height; the twelve tubes which are attached to it come respectively between those which are suspended from the upper cone. Thus the insulation depends on the ebonite pillars, assuming there is no leakage across the air from the edges of the tubes. There is an opening in the outer casing, closed by a door, by means of which the ebonite can be cleaned; the whole is dried by placing inside a small vessel of sulphuric acid. In the centre of the upper cone there is a hole through which a rod passes. The rod is connected with the lower cone and forms the electrode for the insulated cylinders. An ebonite plug, fitting tightly round the rod, can

* Paper read before the British Association in Section A, Leeds, September, 1890, being an Appendix to the Report of the Committee on Electrical Standards.

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be pushed down so as to close the hole and prevent the ingress of dust when the condensers are not in use; when they are being used the plug is removed.

The condensers are placed in the testing-room at the Cavendish Laboratory, and covered by a wood and canvas case to protect them from dust. It is not intended that they should be moveable.

After this description of the condensers, we will proceed to an account of the tests to which they have been subject. The first test was for leakage.

One set of cylinders was put to the earth while the other was connected with a gold leaf electroscope. An attempt was then made to charge them with an electrophorus, or a small electrical machine, but this failed entirely. The electricity either sparked across at places where the tubes were very close together; or, before the potential rose sufficiently to affect the electroscope, small fibres or dust particles which adhered to the tubes formed leaks across; it was clear that the condenser could not be charged to the potential of the machine. Tests were then applied for leakage when the potential was lower. One set of tubes were connected to one pole of a battery—about 36 storage cells were generally employed, having an E.M.F. of 75 volts—the other set being in connection with an insulated key, the second pole of the battery was connected through a galvanometer to the key, and the condenser charged. After an interval, usually about five minutes, contact was again made at the key, the deflection of the galvanometer needle—assuming the E.M.F. of the battery not to have changed—was a measure of the quantity of electricity which had leaked from the condensers in the five minutes.

The amount of leakage was very different in the two condensers, and depended greatly on the dryness of the air and ebonite pillars. Thus, on March 11th, when strong acid had been enclosed for some time, for condenser I., the leak per one minute amounted to about ·1 per cent. of the whole charge, while with condenser II., it was about ten times as great.

The sulphuric acid was removed during the Easter vacation and replaced by calcium chloride, and after this the leak in I. rose to about 1 per cent. per minute or 10 times its former value, while that in II. was from 3 to 4 per cent. of the charge. With the calcium chloride inside the leak was never reduced to less than about ·8 per cent. per minute. In August the condensers having been closed since June with calcium chloride there was a leak in one of about 3 per cent. per minute, while in the same time II. lost about 8 per cent. of its charge.

On August 14th, immediately after this test, the calcium chloride was replaced by sulphuric acid, and the leak was quickly reduced to about 1 per cent. per minute for I. For II., no improvement showed itself at once. The next day the leak in I. was about ·4 per cent. per minute, that in II. had not been greatly reduced. On August 16th the ebonite was, therefore, well cleaned, and air was blown through the tubes of II., and the whole closed for about two hours; the leak had then fallen to about 2 per cent. per minute. By August 18th, the leaks were still more reduced, that in I. being ·2 per cent. per minute, while that in II. was ·6 per cent. per minute.

By the afternoon of this day, the upper parts of the condensers having been open to the air of the laboratory for some six hours during other tests, the leaks had appreciably increased, but they had fallen again the next day when the condensers were left closed during the night.

Thus, during the observations in August, with the exception of those on August 14th, the condenser I. was losing its charge at the rate of about $\frac{1}{500}$th part per 1 minute, while the leakage in II. was some five or six times as great, being about $\frac{1}{100}$th part of the charge per 1 minute.

As will be seen later, several mica condensers were compared with I. and II., the leaks in them were all small, and did not exceed more than $\frac{1}{500}$th per minute.

We come now to the experiments for determining the capacities of the two condensers. Of these, three independent series were made, viz., in December, 1889, May and June, 1890, and August, 1890.

The method, already referred to, was used. Fig. 2 gives a diagram of the method; in Fig. 3, the connections actually employed are shown. With the notation employed, *Phil. Mag.*, August, 1884.

We have, if C be the capacity of the condenser, n the number of times it is charged per 1 second.

$$n\,C = \frac{a\left\{1 - \frac{a^2}{(a+c+g)(a+b+d)}\right\}}{c\,d\left\{1+\frac{a\,b}{c\,(a+b+d)}\right\}\left\{1+\frac{a\,g}{d\,(a+c+g)}\right\}}$$

In most of the experiments about to be described, we had the following values in legal ohms:—

$a = 10$ $\quad d = 1{,}000$
$b = 18$ $\quad g = 17{,}600$

while c, which was the adjustable arm, varied from 6,000 to 15,000.

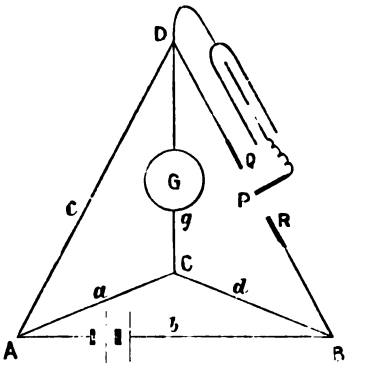

Fig. 2.—Diagram of arrangements for determining the capacities of the Air Condensers.

With these values, the only correction which need be included is the last factor in the denominator, and we may write

$$n\,C = \frac{a}{c\,d\left\{1+\frac{a\,g}{d\,(a+c+g)}\right\}}$$

The resistances were taken from a legal ohm box belonging to the laboratory; the various coils in this box were carefully compared with each other by Mr. Searle, and found to be consistent with each other, at any rate to within 1 in 10,000. The coils were also compared with the standards of the Association, and it was found that at 16° they were greater than

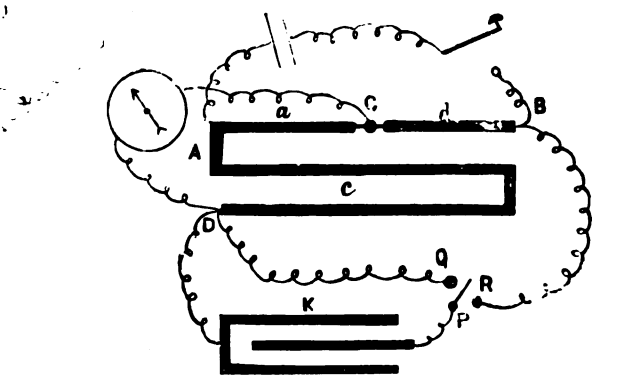

Fig. 3.—Actual connections employed in determining the capacities of the Air Condensers.

legal ohms in the ratio of 1·0011 to 1. The standard temperature adopted in the experiments was 17°, and since the coefficient of increase of resistance of the box is about ·0003 per 1°C., the resistances require to be multiplied by 1·0014, to reduce them to legal ohms. In some cases, in the value of c, coils from a B.A. unit box, containing coils of ten, twenty, thirty, and forty thousand B.A. units were employed.

The values found for these coils by myself in these terms of the legal ohm box showed that they were very consistent with each other, and that the nominal 10,000 B.A.U. was equal to 9,880 legal ohms, as measured by the legal ohm box.

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In the comparisons of two condensers certain coils from a megohm box were used; the value of each of these was also determined. They were as follows:—

1 ..	98,731	Legal ohms of standard box.
2 ...	98,625	,, ,,
3 ...	98,698	,, ,,
4 ...	98,735	,, ,,
9 ...	98,725	,, ,,
10 ...	98,776	,, ,,

In the experiments on Dr. Muirhead's condensers, the vibrating commutator described in Prof. Thomson's Paper, *Phil Trans.*, 1883; or in my Paper, *Phil. Mag.*, 1884, was used, and that with complete success. In the experiments about to be described, this was replaced by a rotating commutator, which had been fitted up by Prof. Thomson and Mr. Searle for their experiments on the other value of "v," and which possesses certain advantages over the other form. Dr. Muirhead and Dr. Fleming have also used a somewhat similar arrangement of apparatus. Fig. 4 shows the arrangement. The split ring commutator is carried on the axle H K, which is driven by a water motor. Two wire springs, Q R, are in contact with the two halves of the commutator respectively, and as it rotates the brush P, made of very fine brass wire, is brought into communication alternately with Q and R. The disc, L, M, was of iron, and its mass helped to steady the motion. On one face of the disc a series of circles were drawn forming a number of

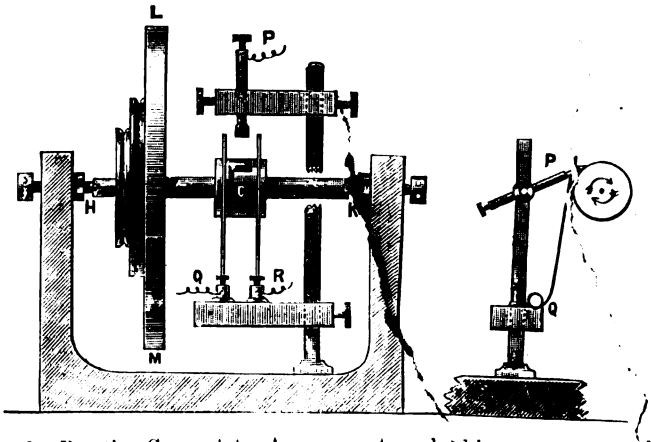

Fig. 4.—Rotating Commutator Arrangement employed in connection with the determination of the capacities of the Air Condensers.

annuli. The successive annuli were divided each into a different number of divisions by radial marks. Thus in the innermost annulus there were four, on the next five, and so on. The disc as it rotated, was watched in the usual stroboscopic manner through two slits on two pieces of thin metal carried by the prongs of a tuning fork, which made about 64 vibrations per second.

When the frequencies of the disc and of the fork were in certain simple ratios to each other, the corresponding pattern on the disc was seen in a steady position. The driving pulley of the motor carried a second band, which passed over an idle pulley near the observer at the tuning fork, and the speed of the motor and hence of the disc was partly adjusted by varying the flow of water, partly by friction on this band until the desired pattern was seen in the steady position; this position was easily maintained by varying the friction on the string. The tuning fork drove a second fork an octave above itself in frequency. This fork was mounted near the standard fork of the Laboratory, and the beats between the two were counted. The frequency of the standard fork was determined by Prof. Thomson and Mr. Searle for their experiments on "v" recently communicated to the Royal Society. They found that it had changed slightly since it was determined by Lord Rayleigh, and give as the result of their experiments, frequency at temperature $t°$

$$= 128{\cdot}105\,\{\,1 - (t - 16)\,{\cdot}00011\,\}$$

The driven fork was always adjusted to a slightly lower frequency than that of the standard, so that there were about 20 beats to the minute between the two. During any series of observations 10 beats were repeatedly counted, but they rarely varied during the series sufficiently to affect the result. The commutator was designed and partly constructed by Mr. Searle, who observed at the tuning fork throughout. A little attention was required to secure good contact between the springs, Q, R, and the rotating parts, and also to adjust the brush, P, but with moderate care in the adjustments the apparatus worked perfectly.

The galvanometer was one constructed in the laboratory; it had a resistance of 17,600 ohms, with a long silk fibre suspension— a quartz fibre would have been an improvement.

Its sensitiveness was such that 1 scale division corresponded to $\cdot 83 \times 10^{-10}$ C.G.S. units of current; the time of swing was 7·2 seconds, so that the sudden discharge through the galvanometer of 10^{-10} C.G.S. units of electricity produced a throw of one division, or, in other words, the quantity which, when discharged suddenly through, gave a throw of γ divisions, $\gamma \times 10^{-10}$. This was determined by discharging through the galvanometer a condenser of capacity ·1 microfarad when charged to 1 volt, the throw observed was 100 divisions, while the steady current due to an E.M.F. of ·001 volt produced a deflection of 72 divisions.

The observations were made by varying c. There was a commutator in the battery circuit; in each position of this commutator two values of c were taken and the corresponding resting points of the spot on the scale observed. From these the value of c, which corresponded to the zero position of the spot, was obtained by interpolation.

These observations were made twice for each position of the commutator and the mean taken.

We will give one series as an example:—

August 27, 1890.
Temperature of standard fork, 23·8°
Beats..... 20 in 65·4 sec.
20 in 65·2 sec.

Condenser No. I.

Frequency, 80 approximately.

Position of Commutator.	Zero Reading.	Resistance.	Resting Point.
/	48	5890	47
		5880	51
\	48	5880	46
		5890	49
/	48	5890	48
		5880	51
\	49	5880	46
		5890	50

Temperature of coils, 17·5deg.
Beats 20 in 64·8, at 19·3deg.

It will be seen that between the third and fourth series the galvanometer zero has shifted slightly.

From these we get as the four values of c the following:—

5887·5
5886·6
5888·3
5887·5

Mean 5887·5 at 17·5
Correction to 17° ·9

Value C = 5888·4 at 17°

while the beats are 20 in 65 seconds at 19deg. or ·307 per 1 second; at 19deg. the frequency of the standard is 128·066, thus the frequency of the driven fork is 128·066 – ·307, *i.e.*, 127·759. Thus for the driving fork we have the octave below this, or 63·879, while the frequency of the commutator is 5/4 of this.

Hence in this series

$$n = 79{\cdot}849 \qquad c = 5888{\cdot}4$$

The accuracy attained in this series is a fair specimen of the whole.

With these explanations we proceed to give the results in tabular form, showing the date, the values of n and c, and

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the resulting value of C. The wire by which the condenser was connected to the commutator, together with the commutator itself, had a certain capacity which was determined in the same way, merely disconnecting the wire from the condenser. In the observations in December and June we found

$$a = 10 \quad d = 98{\cdot}730 \quad c = 28{\cdot}460 \quad n = 63{\cdot}9$$

whence the capacity of the wires is ·0000625 microfarads; while in August, after the apparatus had been set up afresh in a different position with new connecting wires, the value of c was 22,200 and the capacity ·0000799 microfarads; for the wires, the values of c could be determined to about 1 per cent.

In the table the value of C has been corrected for the capacity of the wires.

Table I.—*Condenser I.*

Date.	Value c.	Value n.	C, in microfarads.	Mean of series.
Dec. 31, 1889.....	14,762·5	31·95	·0 1025	
	7,372·3	63 90	·021016	·021020
	5,894·3	79·875	·021019	
May 2?, 1890 ..	14,772·9	31·93	·021023	
	7,376·5	63·86	·021017	·021022
	5,896·4	79·825	·021025	
June 16, 1890 ...	7,375·0	63·86	·021022	·021022
Aug. 27, 1890 ...	14,745·9	31·939	·0210 8	
	7.361·8	63·879	·021027	·021032
	5,888·4	79 849	·0210 0	

Mean of the whole, ·021024 microfarads.

Table II.—*Condenser II.*

Date.	Value c.	Value n.	C, in microfarads.	Mean of series.
Dec. 31, 1889 ...	13.957·1	31·95	·022238	
	6,963·6	65·90	·022249	·022237
	5,575·1	79·875	·022225	
May 20, 1890 ...	13,915·3	31·93	·022271	
	6,957·4	63·86	·022283	·022273
	5,568·2	79·825	·022266	
une 16, 1890 ...	6,953·4	63·86	·022296	·022236
Aug. 27, 1890 ...	13,774·6	31·939	·022523	
	6,876·5	63·879	·02 515	·022519
	5,500·4	79·849	·022518	
Aug. 28, 1890 ...	6,878·6	63·881	·022515	·022515

Table III.—*Giving the Capacity of two Mica Condensers for various frequencies of charge.*

Condenser A.

Frequency.	June 12.	June 14.	June 16.	Mean.
21	·04865	·04886	...	·04886
32	·04883	·04884	...	·04884
64	·04868	·04868	·01864	·04867
80	...	·04859	...	·04859

Condenser B.

21	...	·09642	...	·09642
32	...	·09642	...	·09642
64	...	·09634	·09612	·09638

Taking the air condensers first the tables show that, at any rate for frequencies between 32 and 80 per second, the time of charging has no effect on the capacity, while the individual observations in each series are within 1 in 2,000 of each other.

For Condenser I. the observations at frequency 64 are in all the series the least, but this is not the case with Condenser II.

The capacity of condenser I. shows no change between December, 1889, and June, 1890. The observations in August, 1890, are all rather greater than the earlier series, but the increase about 1 in 2,000 is almost within the error of the experiments. With regard to Condenser II. there is an indication of a rise in its capacity all through. It will be remembered that we have already shown that the insulation resistance of II. is considerably less than that of I.; but it is easy to see that this leak was not sufficient to account for the change, for if R be the resistance of the leak, then our approximate formula becomes

$$n\,C + \frac{1}{R} = \frac{a}{c\,d} \text{ instead of } n\,C = \frac{a}{c\,d}.$$

Now, the current through the Condenser when leaking most was about ·0002 EC, where E is the E.M.F. to which it is charged and c the capacity of the condenser.

Thus the resistance of the leak is $\frac{1}{\cdot 0002 \times C}$ or $\cdot 25 \times 10^{21}$ C.-G.-S. units, since the value of C is $\cdot 02 \times 10^{-15}$. This resistance is 250,000 megohms.

Hence the correction to the capacity $= 1/n\ R = \cdot 0002 \times C/n$, and this is far too small to affect us.

There is no doubt, then, that the capacity of II. altered during the experiments by about 1 per cent., and it will be necessary to take it to pieces and set it up again.

It will be remembered that, in the early part of August, the leak in II. was very great, and it seems probable that the steps taken to discover the cause of the leak have produced a change in capacity. The experiments on II., then, serve merely to show that the capacity can be found by the rotating commutator method to a high degree of accuracy, while those on I. prove that an air condenser, of ·02 microfarad capacity, has been constructed which has retained its capacity unaltered for the eight months between January, 1889, and August, 1890.

The effect of the leak in Condenser II. was still further investigated on August 28th. The plates of II. were connected by a resistance of 30 megohms. Hence the correction to C, which is—

$$-\frac{1}{n\,R}, \text{ becomes } -\cdot 000520 \times 10^{-15}, \text{ when } n = 64.$$

The value of C found with the leak in was $\cdot 023813 \times 10^{-15}$.

Hence, making the correction, C = ·02249 microfarads, which is sufficiently close to the value found without the artificial leak.

Table III. shows that with mica condensers not very much greater in capacity than the air condensers. A change in the frequency of the charge from 21 to 80, produces an appreciable change in the capacity; this, of course, is in consequence of the absorption. With large condensers, as we have already seen, the effect is more marked.

(To be continued.)

THE MARES ENERGY METER.

We are indebted to *Le Génie Civil* for the following particulars with regard to the Marès watt-hour meter, which might be briefly described as a combination of a Snelgrove electric balance and a Thomson current weigher.

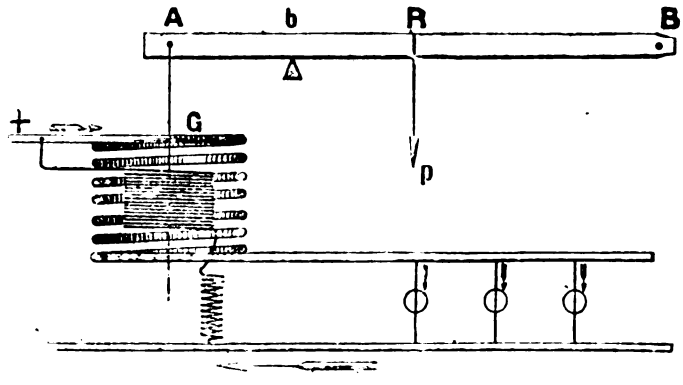

Fig. 1.—Diagram of the Marès Meter.

The watt-hour meter of M. E. Marès may be placed in the category of intermittent integrating meters since it adds up at regular intervals of time (4 minutes) the number of watts expended at that instant in the circuit. Fig. 1 explains the principle of the

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apparatus. G is a thick wire coil in series with the lamps, and inside it is the movable fine wire shunt coil. The latter is suspended from the end A of the lever A B, oscillating about the knife-edge *b*. The electro dynamic action between the coils is equal to a force, *f* (E C), and this may be balanced by a weight, *p*, acting, say, at the point R. Hence we have.

$$f(\mathrm{E\,C}) \times \mathrm{A}\,b = p \times b\,\mathrm{R},$$

or,

$$f(\mathrm{E\,C}) = b\,\mathrm{R} \times \text{a constant}.$$

That is to say, E C at any instant is equal to *b* R multiplied by a constant. What we have to do, therefore, in order to measure E C is to move a weight, *p*, along A B, and to measure off the value of *b* R. This result is attained in the following manner.

The current is shut off from the shunt coil during half of each revolution of M N by means of an appropriate commutator. During the half revolution when the current is diverted from the shunt coil, it is made to wind up the clockwork. One complete revolution of M N causes the scape-wheel of the clockwork to run down by five teeth. One half of the commutator is, therefore, provided with five studs, and as these come into contact with the spring conveying the current five impulses are transmitted to an electro-magnet, which by giving five pulls to its armature winds up the scape-wheel by the amount it has run down.

The Marès meter, which is made by M. Dejardin of Paris, has been used with satisfactory results on the circuits of the Montpellier central lighting station. A perspective view of the meter is given in Fig. 3.

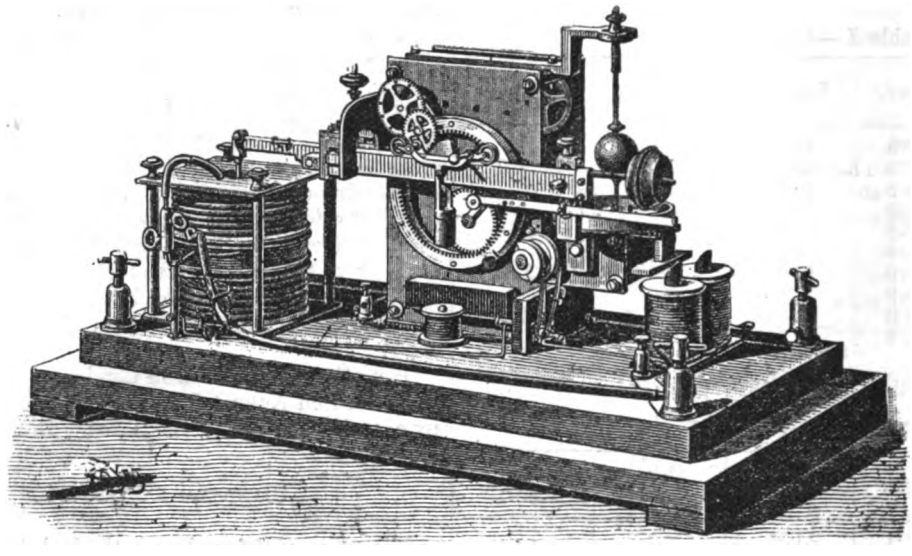

Fig. 3.—The Marès Meter (Back).

The moving weight *p* consists of a rack D (Fig. 2), which rolls along the arm A B, and which carries a small hollow metal cylinder *g*. The apparatus is adjusted by varying the load carried by *g*, and by moving the screw nut *e*. The rack D is actuated by the Lahire gearing M O N, and in virtue of the motion of the inner toothed wheel the rod T moves to and fro, carrying with it the rack D.

The integration is effected every four minutes as stated above. In that space of time, therefore, the rack D has to effect a complete to and-fro movement. The Lahire gearing is worked by clockwork, which is wound up electro-magnetically. The rectilinear motion of the rack D causes the toothed wheel F to rotate, and this in turn gives motion to a train of wheels actuating a registering apparatus. In order that the rotations of F may be proportional to E C, it is

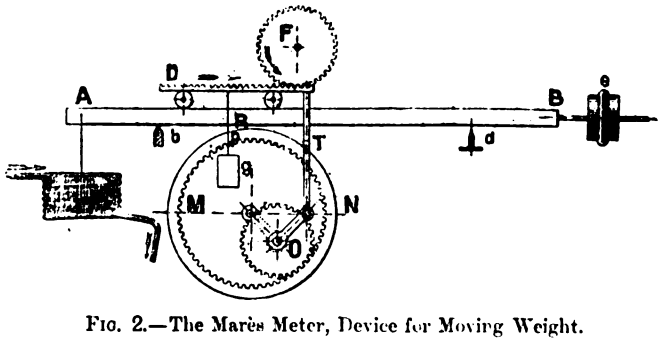

Fig. 2.—The Marès Meter, Device for Moving Weight.

necessary that the rack D should cease to come in contact with it the moment the beam is balanced, and the rack D should not again be engaged with the wheel F until it again commences a forward movement. This is effected in the following manner. When the weight *p* passes the point of equilibrium the beam tilts downwards on to the stop *d*, and the wheel F is disengaged. In order to prevent D from engaging with F on its return journey, the current, which continues to pass through the shunt coil during the whole of the forward movement of the rack, is cut off during the second half revolution of M N. The beam thus maintains such a position during the return journey of the rack as enables it to clear the wheel F. If the series coil of the meter is not traversed by any current the beam tilts over as soon as the rack begins to move forward and nothing is therefore measured.

INDUCTIVE AND EARTH INTERFERENCE WITH TELEPHONE SERVICE.*

BY DR. LOUIS BELL.

Until within the last three or four years the telephone service of this country had gone on its steady course of growth and extension without meeting serious difficulty from interference of extraneous circuits. Of course, the well-known phenomena of cross-talk had made it very clear to all telephone men that they were dealing with a remarkably sensitive instrument; but it required the advent of the alternating current and the electric railway to bring electricians to a realising sense of the conditions that must in the future be contended with. Although the practical features of the case are already known to many telephone engineers, it may be worth while to re-state the matter here. Given a telephone line running parallel to an electric light or power circuit, it finally results that the factors entering into the disturbance produced will be the distance between the lines, the length of parallelism, the self-inductions and resistances of the respective circuits, and the period and strength of the disturbing current. The total effect varies directly with the distance through which the circuits are parallel and inversely with the distance between them. Consequently it is quite possible for very severe induction to take place between lines which nowhere approach each other within several hundred feet, provided the length of parallelism is sufficient. On the other hand, a telephone wire running near a disturbing circuit, even for a very short distance, will be affected in a most marked way. In fact, the amount of induction depends on the ratio between the distance of parallelism and the distance between the lines rather than on the absolute value of either of these.

This fact is not entirely new, but is one to which comparatively little attention has been paid. A pair of cases from the writer's observation will illustrate the point admirably; both were specimens of pure inductive interference from an electric railway circuit. In the one case the telephone wire ran parallel to the disturbing circuit for about a third of a mile with the full width of a rather wide street between them—75ft. or so. The disturbance produced by the variations in the railway current were exceedingly marked, and almost destroyed the usefulness of the telephone. In the other case the trouble was nearly as great, but the entire inter-

* From the *Electrical World* of New York.

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fering portions of the two wires were not more than 100ft. long, running, however, on the same pole about 18in. apart.

Another case that was brought to the writer's attention was a telephone wire between Chicago and Milwaukee, paralleled a large part of the distance by a telegraph line, on which an automatic transmitter was in use, the intervening distance being more than 100 yards. The result was the disabling of the telephone line. Still another example on a small scale was found in a long distance telephone line that ran nearly parallel to a railway circuit for a length of about 100ft. at a distance of about 3ft. The result was very marked interference, so that not only the running of the cars, but the whirr of the dynamos at the power station was distinctly heard. These examples are sufficient to show the importance of considering the distance ratio previously mentioned. In a very large number of places it seems to be forgotten by both the interested parties that to avoid trouble the wires must be kept away from each other. There is too much tendency to fancy that a power circuit will do no harm because it runs parallel to the telephone lines for only a very little distance. A great deal can be learned by locating the various disturbing causes through the pitch of the sounds produced. In some cases of induction complaints of disturbed telephone service were very loud shortly after the advent of an electric road, while on listening at the telephone the sounds proved to be produced by an old and familiar electric light circuit, as could be readily told by the pitch and uniformity of the tone produced.

So much for a view of the phenomena concerned. As regards remedy, in the discussions that have taken place on the subject several things have frequently been forgotten. One of these is that a return wire for the inducing current may or may not completely remedy the difficulty. If the two are closely parallel and the currents are in the same phase, there will be no effect on neighbouring wires; but if, as is always the case in street railway work, the phase of the disturbance is changed by the interposition of the motors, there is likely to be some residual interference with neighbouring wires. In other words, if anything disturbs the balance of the outgoing and returning current, either in quantity or in phase of disturbance, there will be trouble. This is sufficiently exemplified in the case of double trolley railroads where, so long as there is no leakage through the car or along the line, there is little or no trouble with the telephones; but if there is a ground on the car, even in a position where there would be no direct passage of the current to the grounded telephone wires, the trouble will be nearly as great as on a single trolley line. Only a complete return circuit on telephone wires can avoid every trace of interference.

Unfortunately, induction is not the only thing we have to deal with, and some interesting cases have recently come to light of extraordinary difficulty with stray currents in the ground. Perhaps one of the most striking came from London, where the alternating mains of the great Ferranti system produced ground disturbances that caused currents as high as the one-tenth of an ampere on the London telegraph lines, and especially on a circuit that ran from London to Rome, rendering it almost useless.

A similar formidable disturbance was recently observed on the lines of the Commercial Cable Company near New York. This ground interference is something that is comparatively little understood, and ought to receive very careful study both from electric power and telephone electricians. It constitutes by far the most formidable part of the difficulty usually met with. Very severe interference with telephone wires, such as shutters dropping at the exchange, and bells ringing when a car is passing, is almost invariably caused by ground leakage, and can usually be traced to grounds on water or gas pipes that run near to the disturbing conductor. A little care in keeping away from lines that are liable to disturbance would avoid most of the trouble from induction, but that from the ground is very singular in its persistence and erratic ways. We have very little information as to what really becomes of a current after it enters the ground. It certainly appears to stray in a very remarkable manner and without any great regularity of purpose. It would be a great service to practical electricity if all the striking cases of ground interference that come under the notice of telephone managers could be gathered together and used to form some general idea of the conditions in which trouble could be expected, and how far it is possible to avoid it by simple precautions. As it is now, the difficulties encountered by telephone managers are very great, and the remedies, aside from a very complete metallic return, have not been altogether satisfactory. It seems highly probable that if a more careful study of the conditions that follow grounding a variable current were generally made, it might be possible to avoid difficulty with telephone lines from grounds as easily as we now can avoid serious induction by keeping at a reasonable distance, and to secure excellent service without the expense of metallic circuits. The facts in the case have not been collated as yet with the care that the importance of the subject demands; and if this brief discussion of some of the facts involved can stir up sufficient interest in the matter to lead to proper investigation of the very extraordinary behaviour of earth currents, it will have served its purpose. It is more a plea for the study of the complicated and interesting phenomena met with in these disturbances of telephone service than anything of a more scientific and definite character.

A vast store of information on this subject has been accumulated by independent observers in the course of practical experience; and if it could be gathered and utilised the public would undoubtedly soon have the advantage of lessened trouble with so important a factor in business affairs as the modern telephone system. There ought to be full harmony between the telephone and other electrical interests in the matter of interference. The legal aspects of the question are not in a very satisfactory state, and much more good can be done by a thorough policy of arbitration than has been accomplished by more vigorous means. It is pretty clear that the public will not tolerate destruction of its telephonic facilities, nor will it sacrifice its electric light and power. It is a most unfortunate thing that the interests involved have come into collision so often, and it would be of general benefit if the whole subject could be looked into exhaustively and means taken to secure as amicable an adjustment of existing differences as is possible. If it were quite clearly understood just what interferences may be regarded as preventible by simple means and what are unavoidable or can only be escaped by great trouble and expense, the equitable adjustment of the differences now existing between the parties concerned would become very much simpler than it is at present. A thorough study of the phenomena would very much facilitate adjustment of the whole matter, and it is in the hope of stimulating such an investigation by calling attention to some of the conditions to be met, that this brief discussion of the matter has been written.

THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON, D.SC., B.A., M.I.E.E.

(Concluded from page 593.)

I have the means here of illustrating the induction method of measuring permeability. Here is an iron ring, having a cross section of almost exactly one square centimetre. It is wound with an exciting coil supplied with current by two accumulator cells; over it is also wound an exploring coil of 100 turns connected in circuit (as in Rowland's arrangement) with a ballistic galvanometer which reflects a spot of light upon yonder screen. In the circuit of the galvanometer is also included a reversing earth-coil. As a matter of fact this earth-coil is of such a size, and wound with so many convolutions of wire, that when it is turned over, the amount of cutting of magnetic lines is equal to 840,000, or is the same as if 840,000 magnetic lines had been cut once. By adjusting the resistance of the galvanometer circuit it is arranged that the first swing due to the induced current when I suddenly turn over the earth coil is 8·4 scale divisions. Then, seeing that our exploring coil has 100 turns, it follows that when in our subsequent experiment with the ring we get an induced current from it, each division of the scale over which the spot swings will mean 1,000 lines in the iron. I turn on my exciting current. See, it swings about 11 divisions. On breaking the circuit it swings nearly 11 divisions the other way. That means that the magnetising force carries the magnetisation of the iron up to 11,000 lines; or, as the cross-section is about 1 square centimetre, $B = 11{,}000$. Now, how much is H? The exciting coil has 180 windings, and the exciting current through the amperemeter is just 1 ampere. The total excitation is just 180 "ampere-turns." We must, according to our rule given above, multiply this by 1·2566 and divide by the mean circumferential length of the coil, which is about 32 centimetres. This makes $H = 7$. So if $B = 11{,}000$ and $H 7$, the permeability (which is the ratio of them) is about 1,570. It is a rough and hasty experiment, but it illustrates the method.

Bosanquet's experiments settle the debated question whether the outer layers of an iron core shield the inner layers from the influence of magnetising forces. Were this the case, the rings made from thin bar iron should exhibit higher values of B than do the thicker rings. This is not so; for the thickest ring, G, shows throughout the highest magnetisations.

(B) Bar Method.—This method consists in employing a long bar of iron instead of a ring. It is covered from end to end with the exciting coil, but the exploring coil consists of but a few turns of wire situated just over the middle part of the bar. Rowland, Bosanquet, and Ewing have all employed this variety of method; and Ewing specially used bars the length of which was more than 100 times their diameter, in order to get rid of errors arising from end-effects.

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

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(C) Divided Bar Method.—This method, due to Dr. Hopkinson,[34] is illustrated by Fig. 17.

The apparatus consists of a block of annealed wrought iron about 18in. long, 6½ wide, 2 deep, out of the middle of which is cut out a rectangular space to receive the magnetising coils.

The test samples of iron consist of two rods, each 12·65 millimetres in diameter, turned carefully true, and slide in through holes bored in the ends of the iron blocks. These two rods meet in the middle, their ends being faced true so as to make a good contact. One of them is secured firmly, and the other has a handle fixed to it, by means of which it can be withdrawn. The two large magnetising coils do not meet, a space being left between them. Into this space is introduced the little exploring coil, wound upon an ivory bobbin, through the eye of which passes the end of the movable rod. The exploring coil is connected to the ballistic

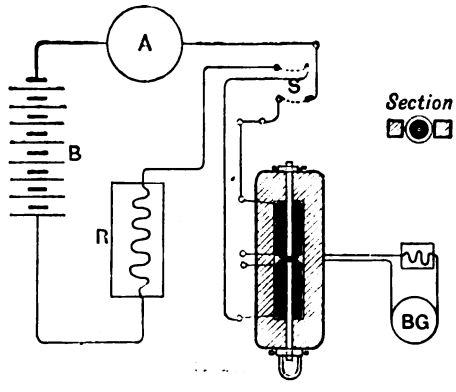

FIG. 17.—Hopkinson's Divided Bar Method of Measuring Magnetic Permeability.

galvano-meter, B G, and is attached to an india-rubber spring (not shown in the figure), which, when the rod is suddenly pulled back, causes it to leap entirely out of the magnetic field. The exploring coil had 350 turns of fine wire; the two magnetising coils had 2,008 effective turns. The magnetising current, generated by a battery, B, of eight Grove cells, was regulated by a variable liquid resistance, R, and by a shunt resistance. A reversing switch and an ampere-meter, A, were included in the magnetising circuit. By means of this apparatus the simple rods to be experimented upon could be submitted to any magnetising forces, small or large, and the actual magnetic condition could be examined at any time by breaking the circuit and simultaneously withdrawing the movable rod. This apparatus, therefore, permitted the observation separately of a series of increasing (or decreasing) magnetisations without any intermediate reversals of the entire current. Thirty-

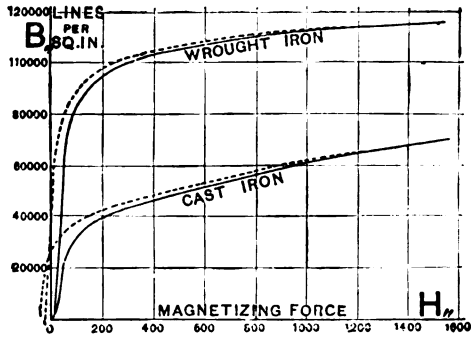

FIG. 18.—Curves of Magnetisation of Iron.

five samples of various irons of known chemical composition were examined by Hopkinson, the two most important for present purposes being an annealed wrought iron and a grey cast iron, such as are used by Messrs. Mather and Platt in the construction of dynamo machines. Hopkinson embodied his results in curves, from which it is possible to construct, for purposes of reference, numerical Tables of sufficient accuracy to serve for future calculations. The curves of these two samples of iron are reproduced in Fig. 18, but with one simple modification. British engineers who unfortunately are condemned by local circumstances to use inch measures instead of the international metric system, prefer to have the magnetic facts also stated in terms of square inch units instead of square centimetre units. This change has been made in Fig. 18, and the symbols $B_{\prime\prime}$ and $H_{\prime\prime}$ are chosen to indicate the numbers of magnetic lines to the square inch in iron and in air respectively.

[34] *Phil. Trans.* 1885, p. 456.

The permeability, or multiplying power of the iron is the same, of course, in either measure. In Table II. are given the corresponding data in square inch measure; and in Table III. the data in square centimetre measure for the same specimens of iron.

Table II.—(*Square Inch Units.*)

Annealed Wrought Iron.			Grey Cast Iron.		
$B_{\prime\prime}$	μ	$H_{\prime\prime}$	$B_{\prime\prime}$	μ	$H_{\prime\prime}$
30,000	4,650	6·5	25,000	763	32·7
40,000	3,877	10·3	30,000	756	39·7
50,000	3.031	16·5	40,000	258	155
60,000	2,159	27·8	50,000	114	439
70,000	1,921	36·4	60,000	74	807
80,000	1,409	56·8	70,000	40	1480
90,000	907	99·2	—	—	—
100,000	408	245	—	—	—
110,000	166	664	—	—	—
120,000	76	1581	—	—	—
130,000	35	3714	—	—	—
140,000	27	5185	—	—	—

Table III.—(*Square Centimetre Units.*)

Annealed Wrought Iron.			Grey Cast Iron.		
B	μ	H	B	μ	H
5,000	3,000	1·66	4,000	800	5
9,000	2,250	4	5,000	500	10
10,000	2,000	5	6,000	279	21·5
11,000	1,692	6·5	7,000	133	42
12,000	1,412	8·5	8,000	100	80
13,000	1,083	12	9,000	71	127
14,000	823	17	10,000	53	188
15,000	526	28·5	11,000	37	292
16,000	320	50	—	—	—
17,000	161	105	—	—	—
18,000	90	200	—	—	—
19,000	54	350	—	—	—
20,000	30	666	—	—	—

It will be noted that Hopkinson's curves are double, there being one curve for the ascending magnetisations, and a separate one, a little above the former, for descending magnetisations. This is a point of a little importance in designing electro-magnets. Iron, and particularly hard sorts of iron, and steel, after having been subjected to a high degree of magnetising force, are subsequently to a lesser magnetising force found to retain a higher degree of magnetisation than if the lower magnetising force had been simply applied. For example, reference to Fig. 18 shows that the wrought iron, where subjected to a magnetising force gradually rising from zero to $H_{\prime\prime}=200$, exhibits a magnetisation of $B_{\prime\prime}=95,000$; but after $H_{\prime\prime}$ has been carried up to over 1,000, and then reduced again to 200, $B_{\prime\prime}$ does not come down again to 95,000, but only to 98,000. Any sample of iron which showed great retentive qualities, or in which the descending curve differs widely from the ascending curve, would be unsuitable for constructing electro-magnets, for it is important that there should be as little residual magnetism as possible in the cores. It will be noted that the curves for cast-iron show more of this residual effect than do those for wrought-iron. The numerical data in Tables II. and III. are means between the ascending and descending values.

As an example of the use of the Tables, we may take the following:—How strong must the magnetising force be in order to produce in wrought-iron a magnetisation of 110,000 lines to the square inch? Reference to Table II., or to Fig. 18, shows that a magnetising field of 664 will be required, and that at this stage of the magnetisation the permeability of the iron is only 166. As there are 6·45 square centimetres to the square inch, 110,000 lines to the square inch corresponds very nearly to 17,000 lines to the square centimetre, and $H_{\prime\prime}=664$ corresponds very nearly to $H=100$.

Traction Methods.

Another group of methods of measuring permeability is based upon the law of magnetic traction. Of these there are several varieties.

(D) Divided Ring Method.—Mr. Shelford Bidwell has kindly lent me the apparatus with which he carried out this method. It consists of a ring of very soft charcoal iron rod 6·4 millimetres in thickness, the external diameter being eight centimetres, sawn into two half rings, and then each half carefully wound over with an exciting coil of insulated copper wire of 1,929 convolutions in total. The two halves fit neatly together; and in this position it constitutes practically a continuous ring. When an exciting current is

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passed round the coils both halves become magnetised and attract one another. The force required to pull them asunder is then measured. According to the law of traction, which will occupy us in the second lecture, the tractive force (over a given area of contact) is proportional to the square of the number of magnetic lines that pass from one surface to the other through the contact joint. Hence the force of traction may be used to determine B ; and on calculating H as before, we can determine the permeability. The following Table IV. gives a summary of Mr. Bidwell's results :—

Table IV.—(*Square centimetre measure*). *Soft Charcoal Iron.*

B	μ	H
7,390	1899·1	3·9
11,550	1121·4	10·3
15,460	386·4	40
17,330	150·7	115
18,470	88·8	208
19,330	45·3	427
19,820	33·9	585

(*E*) *Divided Rod Method.*—In this method, also used by Mr. Bidwell, an iron rod hooked at both ends was divided across the middle, and placed within a vertical surrounding magnetising coil. One hook was hung up to an overhead support ; to the lower hook was hung a scale-pan. Currents of gradually-increasing strength were sent around the magnetising coil from a battery of cells, and note was taken of the greatest weight which could in each case be placed in the scale-pan without tearing asunder the ends of the rods.

(*F*) *Permeameter Method.*—This is a method which I have myself devised for the purpose of testing specimens of iron. It is essentially a workshop method, as distinguished from a laboratory method. It requires no ballistic galvanometer, and the iron does not need to be forged into a ring or wound with a coil. For carrying it out a simple instrument is needed, which I venture to denominate as a *permeameter*. Outwardly, it has a general resemblance to Dr. Hopkinson's apparatus, and consists, as you see (Fig. 19) of a rectangular piece of soft wrought-iron, slotted out to receive a magnetising coil, down the axis of which passes a brass tube. The block is 12in. long, 6½in. wide, and 3in. in thickness. At one end the block is bored to receive the sample of iron that is to be tested. This consists simply of a thin rod about a foot long, one end of which must be carefully surfaced up. When it is placed inside the magnetising coil, and the exciting current is turned on, the rod sticks tightly at its lower end to the surface of the iron block ; and the force required to detach it (or, rather, the square root of that force) is a measure of the permeation of the magnetic lines through its end-face. In the first permeameter which I constructed the magnetising coil is 13·64 centimetres in length, and has 371 turns of wire. One ampere of exciting current consequently produces a magnetising force of H=34. The wire is thick enough to carry 30 amperes, so that it is easy to reach a magnetising force of 1,000. The current I now turn on is 25 amperes. The two rods here are of "charcoal iron" and "best iron" respectively; they are of quarter,

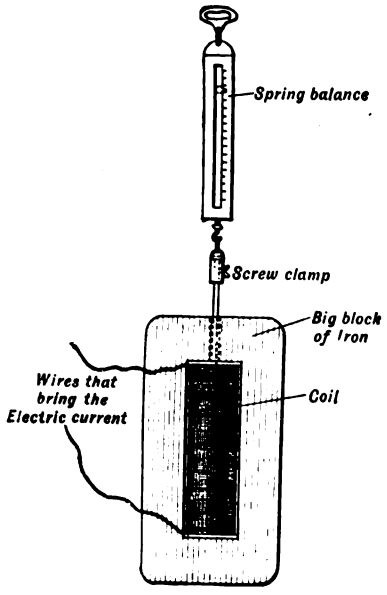

Fig. 19.—The Permeameter.

inch square stuff. Here is a spring balance graduated carefully and provided with an automatic catch so that its index stops at the highest reading. The tractive force of the charcoal iron is about 12⅓lb., while that of the "best" iron is only 7½lb. B is about 19,000 in the charcoal iron, and H being 850, μ is about 22·3. The law of traction which I use in calculating B will occupy us much in the next lecture, but meantime I content myself in stating it here for use with the permeameter. The formula for calculating B when the core is thus detached by a pull of P pounds, the area of contact being A square inches, is as follows :—

$$B = 1{,}317 \times \sqrt{P \div A} + H.$$

Curves of Magnetisation and Permeability.

In reviewing the results obtained, it will be noted that the curves of magnetisation all possess the same general features, all tending toward a practical maximum, which, however, is different for different materials. Joule expressed the opinion that "no force of current could give an attraction equal to 200lb. per square inch," the greatest he actually attained being only 175lb. per square inch. Rowland was of opinion that the limit was about 177lb. per square inch for an ordinary good quality of iron, even with infinitely great exciting power. This would correspond roughly to a limiting value of B of about 17,500 lines to the square centimetre. This value has, however, been often surpassed. Bidwell obtained 19,820, or possibly a trifle more, as, in Bidwell's calculation, the value of H has been needlessly discounted. Hopkinson gives 18,250 for wrought iron, and 19,840 for mild Whitworth steel. Kapp gives 16,740 for wrought iron, 20,460 for charcoal iron in sheet, and 23,250 for charcoal iron in wire. Bosanquet found the highest value in the middle bit of a long bar to run up in one specimen to 21,428, in another to 29,388, in a third to 27,688. Ewing, working with extraordinary magnetic power, forced up the value of B in Lowmoor iron to 31,560 (when μ came down to 3), and subsequently to 45,350. This last figure corresponds to a traction exceeding 1,000 pounds to the square inch.

Cast iron falls far below these figures. Hopkinson, using a magnetising force of 240, found the values of B to be 10,783 in grey cast iron, 12,408 in malleable cast iron, and 10,546 in mottled cast iron. Ewing, with a magnetising force nearly fifty times as great, forced up the value of B in cast iron to 31,760. Mitis metal, which is a sort of cast wrought iron, being a wrought iron rendered fluid by addition of a small percentage of aluminium, is, as I have found, more magnetisable than cast iron, and not far inferior to wrought iron. It should form an excellent material for the cores of electro-magnets for many purposes where a cheap manufacture is wanted.

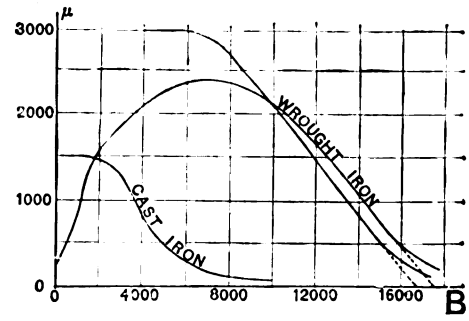

Fig. 20.—Curves of Permeability.

A very useful alternative mode of studying the results obtained by experiment is to construct curves, such as those of Fig. 20, in which the values of the permeability are plotted out vertically in correspondence with the values of B plotted horizontally. It will be noticed that in the case of Hopkinson's specimen of annealed wrought iron, between the points where B=7,000 and B=16,000, the mean values of μ lie almost on a straight line, and might be approximately calculated from the equation—

$$\mu = (17{,}000 - B) \div 3{\cdot}5.$$

Hysteresis.

I have already drawn attention to the difference between the ascending and descending curves of magnetisation, and may now point out that this is a part of a set of general phenomena of residual effects. The best known of these effects is, of course, the existence in some kinds of iron, and notably in steel, of a remanent or sub-permanent magnetisation after the magnetising force has been entirely removed. To this retardation of effects behind the causes that produce them the name of "hysteresis" has been given by Prof. Ewing. If a piece of iron is subjected to a magnetising force which increases to a maximum, then is decreased

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down to zero, then reversed and carried to a negative maximum, then decreased again to zero, and so carried round an entire cycle of magnetic operations, it is observed that the curves of magnetisation form a closed area similar in general to those shown in Fig. 21. This closed area represents the work which has been wasted or dissipated in subjecting the iron to those alternate magnetising forces. In very soft iron, where the ascending and descending curves are close together, the enclosed area is small; and, as a matter of fact, very little energy is dissipated in a cycle of magnetic operations. On the other hand, with hard iron, and particularly with steel, there is a great width between the curves, and there is great waste of energy. Hysteresis may be regarded as a sort of internal or molecular magnetic friction, by reason of which alternate magnetisations cause the iron to grow hot. Hence the importance of understanding this curious effect, in view of the construction of electro-magnets that are to be used with rapidly alternating currents. The following figures of Table V. give the number of watts (1 watt = $\frac{1}{746}$ of a horse-power) wasted by hysteresis in well-

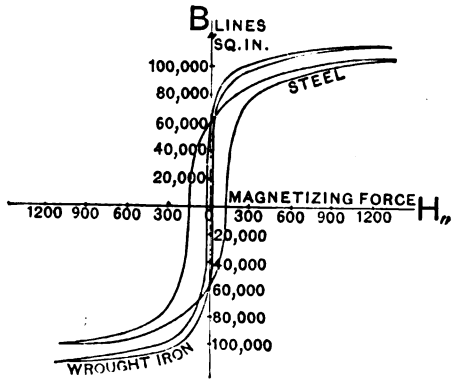

FIG. 21.—Curves of Hysteresis

laminated soft wrought iron when subjected to a succession of rapid cycles of magnetisation.

Table V.—*Waste of Power by Hysteresis.*

B	$B_{\prime\prime}$	Watts wasted per cubic foot at 10 cycles per second.	Watts wasted per cubic foot at 100 cycles per second.
4,000	25,800	40	400
5,000	32,250	57·5	575
6,000	38,700	75	750
7,000	45,150	92·5	925
8,000	51,600	111	1,110
10,000	64,500	156	1,500
12,000	77,400	206	2,060
14,000	90,300	262	2,620
16,000	103,200	324	3,240
17,000	109,650	394	3,910
18,000	116,100	487	4,870

It will be noted that the waste of energy increases as the magnetisation is pushed higher and higher in a disproportionate degree, the waste when B is 18,000 being six times that when B is 6,000. In the case of hard iron or of steel the heat waste would be far greater.

Another kind of after-effect was discovered by Ewing, and named by him "viscous hysteresis." This is the name given to the gradual creeping up of the magnetisation when a magnetic force is applied with absolute steadiness to a piece of iron. This gradual creeping up may go on for half an hour or more, and amount to several per cent. of the total magnetisation.

Another important matter is that all such actions as hammering, rolling, twisting, and the like, impair the magnetic quality of annealed soft iron. Annealed wrought-iron which has never been touched by a tool shows hardly any trace of residual magnetisation, even after the application of magnetic forces. But the touch of the file will at once spoil it. Sturgeon pointed out the great importance of this point. In the specification for tenders for instruments for the British Postal Telegraphs, it is laid down as a condition to be observed by the constructor, that the cores must not be filed after being annealed. The continual hammering of the armature of an electro-magnet against the poles may in time produce a similar effect.

Fallacies and Facts about Electro-Magnets.

I will conclude this lecture by stating a few of the fallacies that are current about electro-magnets, and will add to them a few facts, some of which seem paradoxical. The refutation of the fallacies, and the explanation of the facts will come in due course.

Fallacies.—The attraction of an electro-magnet for its armature varies inversely, as the square of its distance from the poles.

The outer windings of an electro-magnet are necessarily less effective than those that are close to the iron.

Hollow iron cores are as good as solid cores of the same size.

Pole-pieces add to the lifting power of an electro-magnet.

It hurts an electro-magnet (or, for that matter, a steel magnet) to pull off the keeper suddenly. [It is the sudden slamming on that in reality hurts it.]

The resistance of the coil of an electro-magnet ought to be equal to the resistance of the battery.

A coil wound left-handedly magnetises a magnet differently from a coil wound right-handedly. [It is not a question of winding of coil, but of circulation of current.]

Thick-wire electro-magnets are less powerful than thin-wire electro-magnets.

A badly insulated electro-magnet is more powerful than one that is well insulated.

A square iron core is less powerful (as Dal Negro says, eighteen-fold!) than a round core of equal weight.

The attraction of an electro-magnet for its keeper is necessarily less strong (one-third according to Du Moncel) sideways than when the keeper is in front of the poles.

Putting a tube of iron outside the coils of an electro-magnet makes it attract a distant armature more powerfully.

Facts.—A bar electro-magnet with a convex pole holds on tighter to a flat-ended armature than one with a flat pole does.

A thin round disc of iron laid upon the flat round end of an electro-magnet (the pole end being slightly larger than the disc) the disc is not attracted, and will not stick on, even if laid down quite centrally.

If a flat armature of iron be presented to the poles of a horse-shoe electro-magnet the attraction at a short distance is greater, if the armature is presented flankways, than if it is presented edgeways. On the contrary, the tractive force in contact is greater edgeways than flankways.

Electro-magnets with long limbs are practically no better than those with short limbs for sticking on to masses of iron.

THE SHERRIN ELECTRICALLY PROPELLED BATH CHAIR.

We witnessed on Tuesday afternoon last some trials of the electrically-propelled Bath chair, devised by Mr. J. Vaughan Sherrin, to whose battery and other inventions we alluded in our editorial columns last week. The Bath chair, which weighs 200lb., is of wicker-work, and of the usual shape, and is mounted on wheels of the tricycle type. The primary cells, 18 in number, and weighing 80lb., are placed on a large tray, suspended between the wheels behind the chair. The motor, a modified two-pole Gramme machine, with laminated field magnets, weighs 38lb., and has a normal output of about ¼ horse-power. The gearing down is effected by chains. The 18 cells contain 1½ gallons of depolarising solution, costing about 6d. a gallon. With this charge the battery is capable of propelling the vehicle along ordinary roads for nine hours, at the rate of about six miles an hour; the zincs and solution then requiring to be renewed. During the runs in question the Bath chair was very easily steered and stopped, and it surmounted without much difficulty a steep and muddy incline. We also witnessed the satisfactory performances of a small rowing boat, fitted with a Sherrin motor and battery.

We append an abstract of a report by Prof. Silvanus Thompson on Mr. Sherrin's devices.

The primary battery used by Mr. Sherrin is a two-fluid battery, in which the anodes are of sheet zinc, and the kathodes are of carbon. In each cell there are three fixed kathodes and two replaceable anodes. Very light plates are used, and the particular construction adopted permits these to be placed very close together, so that the resistance to the flow of electricity internally is very small. The outer cells are of gutta-percha; in them are embedded the porous cells which surround the anodes. The liquid used in the inner cells is simply water, that placed in the outer cells around the carbon kathodes is a depolarising liquid of special composition, capable of being produced at a low cost. It is to the latter that the cells owe their high electromotive force, nearly two volts each, and their excellent staying power. In one of my tests one of these cells gave out a current of 8·75 amperes (average) for 5 consecutive hours, with an electromotive force (average) of 1·88 volts, although the cell was only about half-filled at starting. In another more complete test a cell gave a discharge lasting rather more than nine hours, of an average strength of 6·5 amperes, the average electromotive force over the whole period being 1·99 volts. The amount of zinc consumed was only 73·1 grammes, being at the rate of 1·24 grammes per ampere-hour. This demonstrates that the quantity of

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zinc consumed per(gross) electrical horse-power hour will be almost exactly one pound and one-fortieth of an ounce.

In a third and more elaborate test one of these cells gave a current of the average strength of 7·85 amperes for 9½ hours; the average electromotive force over the whole discharge being 1·74 volts, of which 1·308 volts was available at the terminal as the working number of volts; the total quantity of current discharged was, therefore, about 72·6 ampere-hours. The total evolution of power was 126·17 watt-hours (or about equal to one-sixth of one horse-power for one hour), of which about 31·26 watt-hours were expended upon the internal resistance of the cell, and 94·81 watt-hours (or about one-eighth of one horse-power for one hour) were available for useful purposes. The quantity of zinc consumed during the 9½ hours' discharge was about 90 grammes, or a little less than one-fifth of a pound; and the quantity of depolarising fluid was about half a pint.

The efficiency of these cells when working at a discharge of about eight amperes is about 75 per cent. Taking this figure, and assuming that the motor used with the cells was appropriately constructed and adjusted to run at an efficiency of 60 per cent., it is clear that the total consumption of zinc for an actual net mechanical output of one horse-power would be about 2lb. 14oz. per hour. Each cell, when filled, weighs 6½lb., and yields 11 ampere hours per lb. of gross weight; or at the rate of 39½lb. gross weight per gross horse-power of electrical output.

I know of no battery, primary or secondary, which for a given gross weight of cell will yield as great an output. The economy of zinc is remarkable, the consumption being close to the theoretical limit. I estimate the net cost of electric energy from such cells at 9d. to 10d. per Board of Trade unit.

The motor consists of a modified two-pole Gramme machine, having the field magnets constructed in a special manner, which, while maintaining great mechanical strength admits of very perfect lamination of the iron. It is well designed and soundly constructed, and when properly set is remarkably free from the common vice of sparking at the commutator. The motor tested first by me weighs 40lb., and it is intended for an output of from half to three-quarters of a horse power when placed in a launch or on a tricycle. To give out its full power it should be supplied with current at a pressure of 55 volts, when it runs at a speed of from 1,500 to 2,000 revolutions per minutes, according to circumstances. Considering the size and weight of this motor, and comparing its efficiency with that of the best motors of equal weight or equal power in the market, I consider the performance of Mr. Sherrin's motor very satisfactory. For so small a motor the power is high, being at the rate of one horse-power for only 62lb. of dead weight.

The electrically-propelled Bath-chair is fitted with one of Mr. Sherrin's smaller motors, and is driven by the current derived from ten of his cells. In a short run which I took in it, on unfavourable roads and in muddy weather it ran at about six miles per hour on the level, and ascended a gradient of about one in eight at the rate of about two miles per hour. It was perfectly easy to manage, and the batteries gave no trouble either from spilling or fuming. I consider the electric chair a thoroughly practical and successful vehicle. Of the electrical tricycle I have made no trial pending certain alterations now in progress in its structure.

OBITUARY.

CHARLES HENRY GIMINGHAM.

We greatly regret to announce the death of Mr. C. H. Gimingham, the superintendent and head of the Edison and Swan Electric Light Company's Factory, at Ponder's End. For some time Mr. Gimingham's health had not been good, and by medical advice he passed the greater part of last winter in Egypt, in the hope of effecting a recovery. He returned in the spring somewhat better, but latterly his evidently failing health had given great anxiety to all his friends. His death early yesterday morning has come as a great shock to a wide circle of acquaintances, as well as to his colleagues and those who worked under him. Those of his colleagues who were more intimately acquainted with him were inspired with feelings of very strong attachment to him by his amiable disposition and character.

Mr. Gimingham was born in 1853, and educated at the City of London School. At the age of sixteen he became private assistant to Mr. William Crookes, F.R.S., with whom he remained twelve years, assisting him in his researches on the radiometer and radiant matter, also in his other researches in chemistry. In 1876 he invented his now widely used multiple tube Sprengel air pump, reading a short Paper on the subject before the Royal Society. In July, 1881, he joined the original Swan Company, and superintended the fitting up of their lamp factory at Benwell, Newcastle-upon-Tyne, and introduced his 5-tube form of Sprengel, which has since been almost exclusively used for the exhaustion of incandescent lamps. He also greatly simplified and improved the manufacture of incandescent lamps. On the formation of the Swan United Electric Light Company, in London, who bought up the Swan Company's business, he became manager of their Benwell factory. Again, on their amalgamation with the Edison Company, he was appointed resident superintendent of the Edison and Swan lamp factories at Newcastle-upon-Tyne. During the latter part of 1885 he planned and arranged a new and very extensive factory at Ponder's End for the Edison and Swan Company, and removed to London to manage the same in February, 1886. During the last four years he carried out for the Edison-Swan Company considerable extensions in their works, and up to the last was engaged in the numerous improvements in the manufacturing operations under his care.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 19, 1890.

The Meeting of the New York Street Railway Association.—The event of the past week was the meeting of the New York Street Railway Association at Rochester. It was notable, first, from the fact that it was almost exclusively electrical in the character of the proceedings; and, in the second place, because it was one of the most interesting, not to say amusing, symposiums of electric railway men on record. The Association is composed of the regular street railway managers and superintendents, and has a large membership. The present meeting was especially and intentionally devoted to the question of electric traction, and representatives of the Sprague, Thomson-Houston, and Short systems were present to expatiate on the relative merits of their various devices. The street railway men received the information accorded to them with great gratitude, and showed their lively interest in the matter by putting the electrical experts through about as severe a cross-examination as it has ever fallen to the lot of men to endure. The questions put were of an exceedingly searching character, and the discussion makes very interesting reading for one who desires to compare the current systems of electrical traction. The questions were not wholly confined to electrical details, very searching inquiries being also made into the business relations of the companies, as combination has been more than once broadly hinted at of late. Altogether the debate was very instructive and decidedly amusing.

Electric Light Accidents.—The morning papers were filled recently with a lurid account of an alleged electrical accident. A small boy was said to have been struck by a falling telegraph wire which was crossed by an electric light line, rendered temporarily unconscious, and badly burned. He was even reported to have remained in a dazed condition for many hours after the accident, and a burn was said to have extended clear across the front of his coat, where the "deadly wire" had struck him. On investigation, it appears that no electricity was concerned in the case. A telegraph wire falling from a considerable height with a full sweep struck the boy, cut his face slightly and knocked him down, as might be expected of a long and heavy wire. The dreadful results of electric shock were purely an effort of the imagination, and the burn across the front of the coat turned out on careful inspection to be iron rust from the broken wire which had struck him. It is not uncommon to have accidents charged to electric current which are due to very simple causes, but it is rather rare to find so amusing an example as the present one. Another and more serious accident recently was due to the electric current, but the victim owed the loss of his life to his own carelessness. The papers for several days have been full of "scare" headlines and vivid descriptions of the death of an unfortunate lineman named Kopp, who climbed an iron pole in front of an "uptown" theatre to repair the lamp on a very rainy night. He strapped himself to the pole, and attempted to manipulate the circuit with a pair of steel pliers. The rubber gloves which, by the directions of the Company, he had been instructed to wear in such cases, he had left at the station, and, as a result of his recklessness, was struck dead by the current. The circuit was an underground one, feeding arc lamps, and

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the potential to which the unfortunate man was exposed was something like 1,700 volts. It was a case of reckless neglect of the most ordinary precautions.

Electric Headlights for American Railways.—An electric headlight is coming into extensive use on a number of Western railroads. It is the result of a considerable amount of experimenting, and possesses some interesting features. Only one of the electrodes, between which the arc is formed, is of carbon, the lower negative pole being a copper rod which wastes away very slowly under the action of the current, thus rendering the lamp nearly self-focussing. The dynamo, which is directly attached to a four-cylinder engine, is placed on the top of the boiler between the smokestack and the headlight. The whole apparatus occupies a very small space and weighs but 650lbs. It is controlled by a throttle valve in the cab governing the steam pipe attached to the engine. The headlight itself is of about 2,000 candle-power nominally, and throws a beam straight forward over the track to an effective distance of nearly a mile. Even in stormy weather the track is sufficiently illuminated to show the smallest obstacle, even at a distance of 1,000 or 1,200ft. In practice the apparatus has been found to require very little attention, and to operate to the great satisfaction of the railway authorities. The ability to light the track far enough ahead of the engine to allow stopping the train in case of an obstruction, is so important to safe running, particularly on roads on which the block system is not used, that the electric headlight is likely to take an important place in our railway service.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *September* 24, 1890.

It is very satisfactory to note the manner in which everything connected with the practical use of electricity is coming to the fore in Scandinavia. To all appearances, electrical engineers will find here a good, although necessarily limited, field for their energies. One large installation follows upon another, the most important being, of course, the two large central stations in Stockholm and Copenhagen. Several English firms have sent in tenders, and the result, which will, no doubt, be shortly known, is awaited with considerable interest.

Here the central station met with much encouragement from the public, the number of subscribers having proved considerably in excess of what had been anticipated. The result of this is, that the installation will have to be larger to start with than was originally intended. About 350 subscribers having applied for the electric light, with an aggregate number of about 14,000 incandescent lamps, it was decided to increase the installation from 10,000 to 20,000 lamps, and the engine-power from 1,100 to 1,400 horse-power. It was also decided to increase the capacity of the accumulator battery from 500 lamps for four hours to 1,000 lamps for eight hours. These various extensions will entail an additional expenditure of some Kr.450,000, which amount was voted by the Corporation some two or three months ago. A good many tenders have been received from prominent firms, both in England and Germany, and they correspond, on the whole, well with each other, in some cases almost surprisingly so. The lowest tender is for Kr.1,456,500, and it comprises engines, dynamos, boilers, wires, &c. To this amount will, however, have to be added, according to present calculations, Kr.33,500 for excavations, laying down cables, foundations, &c, making a total of Kr.1,622,000, which is Kr.253,000 in excess of the second and already considerably increased vote.

There has apparently been some misunderstanding or mistake in the calculations, but the great excess is, of course, principally caused by the constantly-increasing number of lamps required, which now reaches 21,600 simultaneously burning lamps, on account of which it has been necessary to increase the steam-power again, this time from 1,400 to 1,800 horse-power. These repeated extra votes are, of course, not very welcome; but, on the other hand, it must be gratifying for the Corporation to see the interest which people take in the matter; and, secondly, it must be preferable to have the extensions at such an early stage, before the actual installation has been taken in hand. The central station, as finally arranged, will be able to supply electric light to the old centre of Copenhagen, comprising the principal streets of the old town, the Amalienborg Palace, the Exchange, the new Art Museum, &c. It is proposed to light by electricity some of the principal squares. The engines will be compound, the boilers tubular, calculated to work at 10 atmospheres' pressure. The largest engines are of 500 horse-power capacity, running at 125 revolutions per minute.

The installation, as far as the Corporation is concerned, ends with the work in the streets; but the Corporation will defray the cost of the line from the streets to the meter for early applicants. From the meter the user must himself pay the installation; but the Corporation is willing to assist by supplying good lamps at wholesale prices. The price has been fixed at 8 öre (1d. = 7½ öre) per 100 watt-hours, with a slight additional charge for the meter. The price is consequently 4⅘ öre per hour for an ordinary 16-candle 55-watt incandescent lamp, the same light from gas costing 2$\frac{7}{10}$ öre per hour. In Hamburg the charge is 4 pfennig (1 pfennig = 1d.) per 50 watt-hours, or 4·4 pfennig per lamp per hour; but then there is a fixed annual charge of 5 marks per lamp. In Berlin the price is 4 pfennig per lamp-hour, with an additional charge of 6 marks per lamp.

CORRESPONDENCE.

ALLEGED MAGNETO-OPTIC E.M.F.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your issue of 19th September, pages 537 and 559, Dr. Sheldon may have taken proper precautions to ascertain if the telephone became silent directly the beam of light was intercepted; but there is nothing in his description of the experiment to render it even probable that he has detected the effect he was looking for. Any closed circuit near vibrating machinery is likely to have induced currents excited in it.—Yours, &c.,

OLIVER J. LODGE.

ELECTRIC LIGHTING IN CHELSEA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of September 19th, under heading "Chelsea," in the Notes, I am glad to see an extract from the surveyor's annual report to the Chelsea Vestry. It is interesting, as a healthy "sign of the times," to note that electric lighting operations are so active, and work already executed of sufficient scope to require reporting to a Vestry.

My object in writing, however, is to point out that these figures are now somewhat obsolete, so far as the Chelsea Electricity Supply Company is concerned, and that they may be misleading, as the date of the surveyor's report is not given.

Since the surveyor prepared his report, this Company's houses have increased to 182 in Chelsea alone, and including those in South Kensington represent 17,300 eight candle power lamps installed, showing a marked improvement in the natural growth of the industry within the last few months.

Indications of the same sort in other districts are doubtless being felt by many of the other supply companies.—Yours, &c.,

W. HOWARD TASKER,
Electrician to the Chelsea Electricity Supply Company.
October 2, 1890.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—Mr. J. R. Chalmers, of 133, St. Vincent-street, Glasgow, will furnish particulars of tenders required for electric lighting, steam, gas engine, and boiler power for the East End Industrial Exhibition, Glasgow.

———Tenders will be received to-day (Friday) up to twelve noon for the lighting, by gas or otherwise, of the district of Sutton, in Surrey. Particulars can be had of Mr. E. W. Crickmay, Public Hall, Sutton.

———The Board of Governors of the Mullingar District Lunatic Asylum invite tenders for supplying and erecting the necessary plant and fittings for an electric light installation at the Asylum. Further particulars are given in our advertisement columns, and copies of plans and specifications and all information can be obtained from Mr. W. Kaye Parry, M.A., 35, Dame-street, Dublin. Tenders have to be addressed to the "Resident Medical Superintendent" at the Asylum on or before 10 a.m. on the 16th instant.

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MESSRS. B. VERITY AND SONS.—Messrs. Verity have this week issued a very complete and comprehensive catalogue of artistic electric light fittings in polished brass or bronze and wrought iron. Many of the designs are of exceptional merit, and in addition to those given in the catalogue under notice, Messrs. Verity and Sons have in their show-rooms at King-street and Regent-street replicas of many of the finest examples of French and Italian girandoles, &c., in mercury-gilt, any of which can be used for the electric light. Amongst the designs in the catalogue which are specially striking may be mentioned 2,797, 2,776, 2,804, 2,165, 2,085, 2,666, 1,741, 1,744, 1,746, 1,803, 1,715, 1,569, 1,625, 1,276, 1,233, 1,267, 2,164, 1,371, 1,712, 1,252, 1,002, 1,029, 1,298, 1,533, 1,198 1,462, and 1,463. Of these, No. 2,066 is a repousse and pierced sconce, with a two-light branch, with hammered leaves and flowers mounted on plush; No. 1,751 is a polished bronze three-light cluster, with hammered leaves and flowers in a handsome vase; No. 1,569 is a polished and lacquered two-light bracket, with vases and scrolls in Louis XVI. style. No. 1,625 is a polished copper frame with mirror centre, arranged for two lights, and mounted on plush (this design is also made and finished in electro silver). No. 1,276 is a wall sconce in polished brass, with a one-light floral branch, mounted on plush. No. 1,298 is a handsome five-light electrolier in the Adams style, with ornamental vases, leaves, rosettes, and pierced holders. No. 1,533 is a polished and lacquered electrolier for three lights, with ornamental leaves and rosettes and pierced coronet, with glass vases, flint stars, blue jewels, and brass rosettes, and forms one of the most effective groups in the catalogue. No. 1,193 is a very chaste design, and shows more completely than anything else in the catalogue the very artistic character of much of the work executed by Messrs. Verity; it is a polished brass electrolier, with ornamental leaves scrolls, &c., for 12 lights. Nos. 1,462 and 1,463 are a pair of polished brass and lacquered portable griffin standards, the latter being a very handsome example of this class of fitting. In addition to the more artistic fittings, a large number of very serviceable brackets, pendants, suspension lights, table lights, &c., are shown, and the catalogue is one of the most complete we have yet seen, consisting of 48 large folio pages of illustrations and 14 pages of price list and explanatory matter.

REMOVAL NOTICE.—The offices of the Newcastle-upon-Tyne Electric Supply Company, Limited, have been removed to the works of the Company at Pandon Dene, Newcastle-upon-Tyne, where all inquiries should in future be addressed.

——— The International Okonite Company (Limited) have removed from 34, Cannon-street, to 98 and 100, Queen Victoria-street, E.C., to which address all communications should be sent.

MESSRS. W. H. ALLEN AND CO. — The new catalogue of this firm has just been issued, and contains illustrations and price lists of their new patent direct-acting engine and dynamo, the "Kapp" dynamo, the "Allen" dynamo, Allen's dynamo and twin engine, Allen's portable electric lighting plant, search light plant, and Allen's twin tandem combined engine and dynamo. On the last page of the catalogue, which contains 16 large quarto pages, are shown illustrations of an air compresser, direct acting fan for ventilation or forced draft, and turbine water wheel for driving dynamos. Full particulars are given of this firm's 105 volt continuous dynamos as well as of their 55 volt, 65, volt, 75 volt, and 130 volt dynamos.

MESSRS. COX AND CO. have just completed a large installation of electric bells for the Constant Springs Hotel, Jamaica, including two of their improved electric reversing annunciators of seventy-five numbers each.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

September 11, 1890.

14,313. R. ALDRIDGE. Palmer's Green. An improved electric fog signal for railways.

14,341. J. E. ROULEZ. London. Improvements in electrical apparatus for reproducing sound.

14,349. SIEMENS BROTHERS and Co. (Limited). London. An improvement in electric meters (Siemens and Halske, Germany).

14,368. L. A. THRANITZ. London. An automatic electric lighting contrivance for staircases.

September 12, 1890.

14,393. W. LUCAS and T. A. GARRETT. London. Improvements in and connected with electrical apparatus for recording the presence of watchmen, workmen, or others.

14,394. F. W. WHITE and E. F. FURTADO. London. Improvements in electric bells.

14,404. C. S. SNELL. Saltash, Cornwall. Improvements in electrical switches.

14,411. J. T. NIBLETT. London. Improvements in secondary batteries.

September 13, 1890.

14,433. A. F. LLOYD. Dulwich. Improvements relating to coin-freed electrical apparatus.

14,459. E. EDWARDS. London. Improvements in electric bells or sounding apparatus (G. Bénard, France).

14,460. E. EDWARDS. London. Improvements in electric bells (G. Bénard, France).

14,482. R. B. EVERED and T. RUDLING. London. An improved connection for electroliers or electric chandeliers.

14,484. R. B. EVERED and T. RUDLING. London. An improved combined electric switch and connecting or coupling device.

September 15, 1890.

14,536. H. J. VOIGT and J. STANDT. London. Improvements relating to means for connecting glow lamps to their holders, and for connecting together the parts of other electrical apparatus.

September 16, 1890.

14,549. S. L. WIRGAND. Glasgow. Improvements in the art of, and apparatus for, telegraphing and telephoning, and similar purposes.

14,553. R. S. HAMPSON and R. FORSTER. Halifax. Improvements in and relating to train signalling apparatus.

14,554. M. LOWE. Wigan. A magnetic and electric penholder, for the purpose of showing certain scientific phenomena.

14,603. W. R. LAKE. London. Improvements in electric signalling apparatus (the Hall Signal Company, United States).

14,604. M. W. DEWEY. London. Improvements relating to the heating of metals and other materials by electricity.

14,609. B. J. B. MILLS. London. Improvements in electrically-propelled vehicles, in the arrangement and connections of the motors and power-transmitting devices thereof, and the method of operating the same, a portion of the invention being applicable to the transmission of power for other uses (E. H. Johnson, United States).

14,613. W. ROBINSON. London. Electric-motor car.

14,624. A. S. ELMORE. London. Improvements in the manufacture of metallic articles by electrolysis, and apparatus for that purpose.

14,627. A. G. MELHUISH. Denmark Park, Surrey. Improvements in shadowless arc electric lamps.

14,634. E. F. INGLEFIELD. London. Improved apparatus for electric light signalling.

SPECIFICATIONS PUBLISHED.

1889.

14,218. FELL (Vyle). Telegraphy. (Price 8d.)

15,958. ENGELBACH and BRIGHT. Preventing excessive heating of electric mains, &c. (Price 8d.)

16,978. MUNRO. Electric series traction. (Price 8d.)

17,115. BACHMANN. Electro-magnetic telegraph apparatus (Price 6d.)

1890.

2,844. ATKINSON. Dynamo armatures. (Price 6d.)

4,103. CAMPBELL. Electric arc lamps. Price 6d.)

6,126. RADCLIFFE. Electrical signalling apparatus. (Price 6d.)

7,836. STITZEL and OTHERS. Electric semaphores. (Price 11d.)

8,086. BAILEY and WARNER. Secondary batteries. (Price 6d.)

9,124. AUBERT. Electric time counters. (Price 6d.)

10,125. KIMBALL and WIRT. Electric cut-outs. (Price 6d.)

10,188. BOULT (Favor). Electric cut-outs. (Price 8d.)

10,577. JENSEN (The European Fire Service and Motor Co.) Electric fire alarm system. (Price 8d.)

11,680. FARMER. Producing sheets of metal by electro-deposition. (Price 6d.)

11,788. PARMLY. Electric arc lamps. (Price 6d.)

COMPANIES' MEETINGS.

The Direct Spanish Telegraph Company (Limited).

The thirty-fourth ordinary general meeting of the Company was held at Winchester House, Old Broad-street, London, E.C., on Tuesday, the 30th day of September, 1890, for the purpose of receiving the Directors' report and accounts, and for transacting the ordinary business of the Company; Sir James Anderson presiding.

Mr. CH. GERHARDI (the Manager) read the notice calling the meeting and the minutes of the last meeting, which were confirmed and signed as correct.

The CHAIRMAN: Gentlemen, you having taken the report as read, I will make such remarks as I deem to be suitable in proposing its adoption. You will remember that I foreshadowed at the last meeting that the International Telegraph Conference would soon be upon us. It has come and gone. I said at our last meeting that this Conference had a new terror in

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store for us; our tariff was and is only 4½d. per word, and there were rumours of still further reductions. Well, the outcome is we have lost one halfpenny per word, and but for the good offices of Mr. Lamb, of H.M.'s Post Office, supported by the delegates from Spain, who were extremely cordial to us, I am afraid we should have lost one penny. I am bound to say, however, that there was no unfriendliness on the part of the Government delegates towards this or any other company. Yet I thought many were fairly eager to get reduced tariffs as far as possible at somebody else's expense, and we have had to let that halfpenny go. It does not seem a large amount to cry about; yet it amounts, with other adjustments, to about £3,500 per annum, and I do not feel sanguine that so small a reduction will give such impulse to our traffic as to recoup this loss. Still, I think, that we may look to some extent to its being recouped, because our traffic has been continually increasing for the past three years—and we may take comfort from the fact that it continues to increase from commercial sources alone—and that the alteration of tariff does not take place until July, 1891. I have often said at these telegraph meetings that code language was now so scientifically arranged that every year we had to lament a reduction at the rate of about one word per annum per message. Last March I told you this rate of reduction had ceased for twelve months, and I am pleased to find that the average length of messages has actually increased by a fraction for the half-year now under review; but our manager says we must not rejoice too much over that, as he suspects one or two causes other than increase of commercial traffic to account for it. I hope he is wrong; but it does seem as if we had got for the present on the ground floor of the effect of code at the low tariff of 4½d. per word. Some of the code words are 10 and 12, and even some that have been sent me are 24 and 25 words in length. I said this time last year "that for the two previous half-years we had carried more messages and made less money;" but at that date (October, 1889), we had got over that adverse condition and seemed to have turned the corner and we were making more money; but to make the £1,592 increase of revenue, as shown in our last report, we had to carry 155,192 more words, and our expenses had increased by £690. For this present half-year, to earn the increased amount of revenue shown in our report, £2,057 1s. 8d. We have transmitted 260,970 more words than in the corresponding half year, and the working expenses have increased by £391, the details of which I have before me, if you desire them. So far, then, I think we are to be congratulated. The prospect of commerce with this country and Spain has greatly improved, and we are at least justified in expecting that the increase of traffic will continue to some extent. We are not unmindful that the proprietors would naturally expect and desire a larger dividend from the increased revenue published in our report. But I would recall to your mind in substance what I said on previous occasions: "We may not as prudent Directors overlook the fact that we have a Debenture Debt of £62,000 at 6 per cent. due in 1894. Circumstances might arise to make it very difficult to renew those debentures upon easier terms—unless our reserve is so strong as to inspire confidence in the stability of our property. We have—and I earnestly congratulate the proprietors upon the fact—a reserve of £20,258: but we have only single cables, and we must forthwith duplex those cables—I wish I could say duplicate them; but we must duplex them at a cost of about £800 to meet the existing and growing traffic so as to make our speed of transmission unsurpassable; and your Directors would like to feel themselves in a position to meet any probable repairs which may be required upon our cables *without entrenching upon the reserve*. With a growing reserve and a sound commercial increase of our traffic such as now exists and has for the last three years continued, our proprietors, I believe, will gladly provide all the money required to pay off the Debenture debt in 1894, and put the 6 per cent. into their own pockets (hear, hear). This is the goal your Directors aim at, and I feel sure you will, as usual, support us (hear, hear). I do not forget that after the reduction of our capital I promised that after the Preference Shares received their 10 per cent. the Ordinary Shares should receive all the remainder of the revenue; but at that time it did not promise more than a return of 2 per cent. It was a poor look out, and having arranged for a reserve to insure the existence of our property, it seemed right to pause and see what the result would be. But since that time, mainly owing to the Treaty of Commerce between England and Spain, the outlook has changed. We must now prepare to duplex our cables, and I hope by 1894 there may exist good and sufficient reasons for duplicating one at least of our sections of cable. For the present, then, we have an increasing revenue and an increasing reserve, a 6 per cent. dividend; we have £2,500 for contingencies, our cables in good order, and I think we may confidently say that the Direct Spanish Company is fast earning a claim to be considered as one of the soundest investments in connection with submarine telegraph property in the city of London. I now move the following resolution:—

"*That the report and accounts now presented be, and are hereby, received and adopted.*"

Mr. E. ETLINGER seconded.

The CHAIRMAN invited discussion.

Mr. DYETT: What is the price of the present debentures bearing 6 per cent. interest?

The CHAIRMAN: I do not know.

Mr. DYETT: I want to know.

The CHAIRMAN, to the Secretary: Can you say?

The SECRETARY: They are not in the market.

Mr. DYETT: They were taken up by the contractors.

The CHAIRMAN: No, no. They were taken by them, but bought afterwards by the Globe Telegraph Company, who now hold them. It is not worth while discussing now.

A SHAREHOLDER: They are due in three years, I think.

The CHAIRMAN: Yes. In May, 1894. Then we shall all want to get debentures at 4 per cent.

Mr. DYETT: They are not for sale.

The CHAIRMAN: It is not worth while. We have looked the matter in the face over and over again.

The motion was then put and carried.

The CHAIRMAN: I beg to move:—

"*That the dividend at the rate of 10 per cent. per annum, less income tax, on the Preference Shares, and the dividend at the rate of 6 per cent. per annum on the ordinary shares, free of income tax, for the half-year ended 30th June, 1890, be and are hereby declared.*"

Mr. ETLINGER seconded.

The motion was carried.

The CHAIRMAN: That concludes this meeting; and I will call upon the Secretary to read the notice convening the extraordinary meeting.

The SECRETARY read the notice.

Mr. DYETT moved:—

"*That Article 71 of the Articles of Association of the Company be and is hereby repealed, and instead thereof the following be a Regulation of the Company:—The Directors shall receive as remuneration for their trouble in the execution of their office the sum of £600 per annum, or such other sum as the Company in General Meeting may from time to time determine, and such remuneration shall be apportioned by the Directors among themselves in such manner as they shall from time to time think fit.*"

He said: I have much pleasure in endorsing this.

Mr. WALTER BARNETT had much pleasure in seconding a motion for voting the Directors what they were absolutely entitled to. It was with the greatest cordiality that he seconded the proposal, as by the existing Articles of Association the Directors were entitled to claim an increased remuneration some time back, but preferred to leave the matter in the shareholders' hands.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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The motion was carried.

The CHAIRMAN returned thanks for the vote. He was gratified that the shareholders should have voted them this amount, as, although the work had been heavy, their fees had not been too large in the past. There were a good many responsibilities connected with the office of a Director, more than the outside public seemed to realise. It was extremely gratifying to have such a vote from the shareholders, as it showed the confidence they reposed in the Board.

Mr. DYETT said that all parties were satisfied, both shareholders and Directors, so that it was satisfactory all round.

Mr. W. BARNETT proposed a cordial vote of thanks to the Chairman for his courteous conduct in the chair.

Mr. G. C. HAWES seconded the motion, which was carried.

The CHAIRMAN expressed his thanks, and said that it would be necessary that they should have a confirmatory meeting after 14 days to confirm the resolution that they had passed that day. Due notice would be given.

The proceedings then terminated.

NEW COMPANIES REGISTERED.

THE COMBINATION TELEPHONE AND ELECTRICAL ENGINEERING COMPANY (LIMITED).—Registered by Ernest Salaman, 65 and 66, Chancery-lane, W.C., with a capital of £20,000 in £1 shares. Object, to carry into effect an agreement made September 17 between E. F. Furtardo of the first part, Charles J. Grist of the second part, and Arthur O'Brien, as trustee on behalf of the Company, of the third part; to acquire exclusive licenses to work certain inventions of telephones, in respect of which provisional protection has been obtained for the United Kingdom, dated March 31 and May 15, and to acquire the business of Charles J. Grist, of 43, Sydney-street, Oxford-road, Manchester; to carry on the business of a telephone, telegraph and electric light company, &c. There shall not be less than three nor more than seven directors. The first are C. J. Grist and E. F. Furtardo; the others to be appointed by the subscribers to the memorandum of association. Qualification, 50 shares. Remuneration: Chairman, £120; other directors, £75 each.

ELMORE'S AUSTRO-HUNGARIAN PATENT COPPER DEPOSITING COMPANY (LIMITED).—Registered by Ashurst, Morris, Crisp, and Co., 6, Old Jewry, E.C., with a capital of £200,000 in £2 shares. Object: To carry into effect an agreement made between Elmore's Foreign and Colonial Patent Copper Depositing Company (Limited), of the first part, Woodhouse and Rawson United (Limited), of the second part, and the Company of the third part; to carry on in Austria, Hungary, and elsewhere, at such places as the Directors of the Company shall think fit, and whether as principals or agents, the business of manufacturers of and dealers in copper and other metals, and all metallic alloys or compounds of the same, and all goods and articles made of copper or other metals and alloys. There shall not be less than three nor more than nine Directors; the first to be appointed by the subscribers to the Memorandum of Association. Qualification, being a shareholder. Remuneration: Chairman, £400; Vice-Chairman, £300; other Directors, £200 each, together with 2½ per cent. upon net profits made from manufacturing and 1 per cent. upon net profits made from sales of patents, licences, or businesses.

J. E. H. GORDON AND CO. (LIMITED).—Registered by Mann and Taylor, 109, New Oxford-street, W.C., with a capital of £50,000 in £10 shares. Object, to acquire the business of J. E. H. Gordon, electrical engineer, with the leasehold premises where the business has been carried on. The first subscribers are:—

	Shares.
J. E. H. Gordon, M.Inst.C.E., 1, Queen's Gate Gardens, S.W.	1
W. J. Rivington, 21, Gledhow-gardens, South Kensington	1
Mrs. Rivington, 21, Gledhow-gardens, South Kensington	1
Mrs. Gordon, 1, Queen's Gate-gardens, S.W.	1
Mrs. Gordon, Horndon Cottage, Campden Hill	1
Miss Eva Gordon, Horndon Cottage, Campden Hill	1
H. Sinclair, 11, Pall-mall	1

J. E. H. Gordon and W. J. Rivington are appointed the first Directors. Qualification, 200 shares. Remuneration not specified.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY, LIMITED.—At a meeting of the Board of Directors of this Company, held on Friday, it was resolved to declare an interim dividend for the quarter ending September 30, 1890, of 15s. per cent. on the ordinary stock, and £1. 10s. per cent. on the preferred stock, less income tax, payable on November 1st, to the stockholders registered on the books of the Company on September 30, 1890.

BERLINER ELECTRICITATS-WERKE.—This Company is paying this year a dividend of 10 per cent, against 8 per cent. last year. According to the *Elektrotechnischer Anzeiger*, it is proposed to raise the capital from six to nine million marks.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended September 26th amounted to £4,970.

B. DELLAGANA AND CO. (LIMITED).—The Directors of this firm of electrotypers, &c., have declared a dividend at the rate of 6 per cent. per annum on the Preference shares and at the rate of 10 per cent. per annum on the Ordinary shares for the half-year to June 30, 1890.

EASTERN TELEGRAPH COMPANY (LIMITED).—This Company announces the payment on October 14th next of interest of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum on the Preference shares of the Company, for the quarter ended September 30th, and the usual interim dividend of 2s. 6d. per share on the Ordinary shares, free of income-tax, in respect of profits for the quarter ended June 30th. The register of transfers will be closed from October 7th to 14th, both days inclusive.

ELMORE'S AUSTRO-HUNGARIAN PATENT COPPER DEPOSITING COMPANY, LIMITED.—The prospectus of this new subsidiary company of the Elmore group was issued on Saturday last. The Austro-Hungarian concern has a capital of £200,000, in 100,000 shares of £2 each, of which 75,000 shares were offered for subscription at a premium of 10s. per share, and 25,000 were accepted in part payment of the purchase money. Payments had to be made: 5s. on application, 15s. on allotment (which includes the premium), 15s. on Nov. 1, 1890, and 15s. on Jan. 1, 1891. The Directors are Sir John H. Morris, K.C.S.I. (Chairman), Mr. James Rock, J.P., Mr. William Elmore, Mr. John Macfarlan, and Lieut.-Gen. George Henry Fraser, R.A. (Managing Director). The consulting metallurgical chemists are Mr. Francis E. Elmore and Mr. Alexander S. Elmore; the secretary is Mr. J. Shurmer; and the offices are at 20, Bucklersbury, London, E.C. The objects of this Company are similar to those of the French company recently issued. The lists opened on Tuesday, and closed the same day for both town and country.

SUBMARINE CABLES TRUST.—Notice is given that on and after the 15th inst., the coupons due in April last will be paid in full by Messrs. Glyn, Mills, and Co., of Lombard-street, between the hours of 10 a.m. and 2 p.m. The coupons should be left with the Bankers for examination four clear days before payment. Certificate holders are requested to present the coupons for April only, and not those payable on Oct. 15th.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ending September 26, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £3,899.

CRICKET.—WOODHOUSE AND RAWSON *v.* APPLETON, BURBEY, AND WILLIAMSON.—A match was played between these elevens at Brentwood, Essex, on Saturday last, ending in an easy win for the former. Score:—Appleton, Burbey, and Williamson—Worsfold, played on, b Howel, 0; Joseph, run out, 8; Grenville, l b w, b Tasker, 27; Williamson, b Thomas, 0; Bevis, b Howell, 4; Burbey, stumped, b Howell, 0; Matthews, 0; Luff-Smith, c Howell, b Tasker, 0; Paine, b Howell, 1; extras, 1; total, 46. Appleton and Neale did not bat. Woodhouse and Rawson—L. Brockman, b Neale, 5; R. J. Jones, c Burbey, b Worsfold, 1; W. R. Long, b Bevis, 46; B. T. Thomas, c Grenville, b Neale, 97; Tasker, run out, 59; Wickens, c Grenville, b Neale, 7; Atkinson, retired, 40; Howell, run out, 17; Moore, not out, 39; Ryan, not out, 10; extras, 10; total, 331. Arthur did not bat.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Sept. 24.	Price Wednesday, Oct. 1.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Sept. 24.	
						£ s. d.		Highest.	Lowest.
			TELEGRAPHS.						
1,381,380	Stock	15/0	Anglo-American	51 52	51 52	5 5 9	Jan., Apr., July, Oct.	51	..
2,809,310	Stock	30/0	Do. Preferred	87½ 88½	87½ 88½	6 4 4	" " "	88½	87½
2,809,310	Stock	..	Do. Deferred	14½ 15½	14½ 15½	..	.. ..	14½	..
25,000	£100	4%	African Direct, 4 per Cent. Debentures	98 101	98 101	3 19 3	January and July ..	101	99½
130,000	10	3/0	Brazilian Submarine	11⅞ 12½	11⅞ 12½	5 6 1	Mar., June, Oct., Dec.	12	11⅞
69,200	100	5%	Do. 5 per Cent. Bonds	100 102	100 102	4 18 0	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103 107	103 107	4 13 6	June and December	..	..
$7,216,000	$100	..	Commercial Cables xd	103 105	102 104	..	..	103⅜	103½
£16,000	£10	8/0	Cuba Submarine	12 12½	11½ 12	7 1 8	February and August	11⅞	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid)	4 4½	4 4½	5 6 8	March & September	..	..
6,000	5	10%	Do. Preference 10%	9 10	9 10	5 0 0	April and October..	..	..
60,710	20	3/6	Direct United States	10⅜ 10⅝	10⅜ 10⅝	6 11 9	Jan., Apr., July, Oct.	10⅝	10⅜
400,000	10	5/6	Eastern	14 14½	14 14½	4 11 3	" "	14½	14½
70,000	10	6%	Do. 6 per Cent. Preference	15 15½	15 15½	3 17 5	" "	..	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	104 107	104 107	3 14 9	May and November	..	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension	14½ 14⅝	14½ 14⅝	4 17 5	Jan., Apr., July, Oct.	14⅝	14½
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100 102	100 102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Aust'n. Gov. Sub.) Debs. 1900	103 106	101 104	4 16 2	January and July ..	..	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	102 105	102 105	4 15 3	" "	..	..
180,227	10	4/3	Globe Telegraph and Trust	8⅜ 9⅛	8⅜ 9⅛	5 9 7	Jan., Apr., July, Oct.	9	8⅛
180,042	10	6%	Do. 6 per Cent. Preference	14⅞ 15	14⅞ 15⅛	3 18 8	" "	14⅞	..
150,000	10	5/0	Great Northern	15⅝ 16⅛	15⅞ 16⅛	4 12 4	Jan., April, and July	16⅛	15
15,000	100	5%	Do. 5 per Cent Debentures, 1881	100 103	100 103	4 17 1	January and July ..	101	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	36 38	36 38	6 11 7	April and October ..	37	36½
33,348	10	4/0	London Platino-Brazilian	6½ 7⅛	6½ 7⅛	5 6 8	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
9,000	8	6/0	Reuter's	8 8½	8⅛ 8⅜	5 14 4	April and October..	..	..
3,381	£100 Cert.	6..	Submarine Cables Trust	113 117	113 117	5 2 7	" "	..	..
15,609	£10	6/6	West African	9 10	9 10	5 0 0	..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99 102	99 102	4 18 0	March & September	99½	..
30,000	10	3/0	West Coast of America	4⅛ 5	4⅛ 5	10 0 0	January and July ..	4⅛	4⅛
150,000	100	8%	Do. Debentures 8%	103 108	102 107	7 9 7	June and December	106	102½
88,321	10	Nil.	West India and Panama	3⅛ 3½	3 3⅛	..	..	3	..
34,563	10	6/0	Do. 1st Preference 6%	11½ 12	11½ 12	5 0 0	April and October..	11⅝	11½
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	14 15	14 15	4 0 0	..	14⅜	14⅛
64,572	15	6/0	Western and Brazilian	11 11½	11⅛ 11⅜	5 2 3	May and November	11⅛	11⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅜ 7	6⅜ 7⅛	..	..	7 1/16	7
26,986	7½	4/6	Do. 5 per Cent. Deferred	4⅞ 5⅛	4⅞ 5⅛	..	..	..	..
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103 106	103 106	5 13 2	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	101 104	103 106	5 13 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	122 127	122 127	5 10 3	May and November	..	..
£175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99 103	99 103	5 16 6	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5⅜	Consolidated Telephone Const. and Maintenance..	1/16 1⅛	⅛ ⅜	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	1/16 ⅛	⅛ ⅜	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅜ 4⅝	4⅜ 4⅝	6 4 4	June and December	4⅛	4⅛
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12 12½	12⅜ 12⅝	..	June and December	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10 10⅜	10 10⅛	5 14 3	" "	12 1/16	..
209,750	1	½%	South of England, Ordinary	1/16 ⅛	⅛ ⅜	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd)..	2⅜ 3	2⅜ 3	..	..	..	..
55,000	5	1/0	United River Plate	3⅛ 4	3⅛ 4	..	January and July ..	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply	2⅛ 2⅜	2⅜ 2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£6 paid)	4 4⅛	4 4⅛	..	..	..	..
42,853	5	..	Westminster Electric Supply	1 1⅛	1 1⅛	..	..	1 1/16	1 1/16
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	1⅛ 2	1⅛ 2	..	..	..	..
63,416	2	0/10	Do. Preference	1⅝ 1⅞	1⅝ 2	..	..	1⅞	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5⅝	5½ 5⅝	..	..	..	..
353,478	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction	7⅜ 8⅛	7⅜ 8⅛	..	..	7⅜	..
46,700	2	10/0	Elmore's Patent Copper Depositing	6 6½	5 5½	..	..	6 1/16	4⅜
20,000	5	..	Fowler-Waring Cables	2⅜ 3	2⅜ 3	..	..	3	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	18 19	18 19	5 5 3	February & August	18⅜	18⅛
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896 xd	102 104	100 102	4 8 3	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5½ 5⅝	5½ 5⅝	3 12 11	..	5⅝	5 1/16
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	43 45	5 6 8	March and July.....	44½	44⅛
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 102	100 102	4 18 0	..	..	..

JABLOCHKOFF'S DISTRIBUTION PATENT

(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 647.—Vol. XXV. FRIDAY, OCTOBER 10, 1890. Price Fourpence.

NOTES.

The views of Mr. Nikola Tesla regarding the relative merits of open-circuit and closed-circuit transformers will be read with interest. They will be found appended to an article entitled "The Hedgehog Transformer," in our present issue. It must, however, be noted that neither Mr. Swinburne nor Mr. Tesla refer to Foucault currents, which cause a waste of energy, the consideration of which is as important as that due to hysteresis or current heating. The growing importance of eddy currents, as the frequency is increased, is the probable cause of the maximum efficiency found by Mr. Tesla at a particular period; and since, according to this authority, converters of the open-circuit type are more efficient than others provided the period is sufficiently increased, it is important that eddy currents should be considered in discussing the question.

We take exception to Mr. Tesla's statement about magneto-motive force. The output of the converter depends on the flux of lines; and this, in conjunction with the frequency of the alternations and the mass of iron, determines the loss of power in hysteresis. For transformers of the same output and size of core the hysteresis will accordingly depend on the length of the iron circuit; and if this is diminished, as in open-circuited transformers, the hysteresis loss will be lessened in proportion. The increased current needed to produce the same flow of lines will cause an additional amount of waste heat; and as this, under certain circumstances, may be less than the saving effected in hysteresis, it may happen that an increase in efficiency results. Our knowledge of hysteresis losses when the currents are rapidly alternating is, however, incomplete, and very little is known of the relative magnitude of the waste due to eddy currents; so that there seems no theoretical ground for supposing that any increase of efficiency attained in this way would be of sufficient importance to outweigh the practical considerations to which Mr. Tesla refers.

The question of the efficiency of transformers is one of very great commercial importance; but the discussion of the details of actions which may or may not exist in hedgehog or other transformers would fill many columns, and since opinions differ so greatly, we do not expect to see the question settled until some efficiency tests are carried out under the conditions of ordinary use. Mr. Swinburne has, we believe, been somewhat misunderstood by Mr. Nikola Tesla, but he has at least made it clear that the consideration of an "all-day efficiency" has been overlooked by those who have merely made tests at different loads. A misunderstanding is, however, the less to be wondered at, as Mr. Swinburne's style has lately lacked lucidity. This, indeed, is shown in his Paper on testing iron, in this issue.

In a recent Note we remarked that a magneto giving, say, a hundred volts is not a sufficient test for house-wiring. We admit that we had Mr. Sidney Evershed's ohm-meter in mind; and are glad to learn from him that the portable generator which is supplied with his ingenious instrument gives a direct and continuous current at a hundred volts with seventy revolutions per minute, many users being in the habit of turning it faster and getting a hundred and fifty, to two hundred volts. We do not think that this is generally known, and hope to give a description of the generator and of the reasons which led to its design.

According to the annual report of the Queensland Post-master-General the telegraph service of that colony has had a very chequered experience during the past year, the country suffering from numerous and extensive floods, which have either swept the poles away or submerged them under water, sometimes for three or four weeks at a stretch. To maintain communication in these circumstances fresh lengths had to be bolted on to the standing poles in order to raise the lines out of the water; and this, while the wires were the refuge of snakes, and every insulator the shelter for a crowd of centipedes, was a task of no small difficulty and danger. It is not surprising, therefore, that the revenue has fallen off by £10,000, and the expenditure increased by £4,000. Some reforms are in contemplation, foremost amongst which is the adoption of an inclusive rate for all telegrams, the addresses to be charged for. Taking warning, however, probably by what has happened in this country, the Australian officials are almost unanimous in their disapproval of registered code addresses. Thirty-one new offices have been opened in the colony, and 565 miles of additional wire erected during the year, making the total miles of wire 17,193.

In another column will be found the report of the first statutory meeting of the International Okonite Company, which was held yesterday. The Okonite and Elmore concerns cannot at present be discussed apart from the Company who have promoted them, for they have not yet acquired any individuality. They differ from the Automatic Machine manufacture and from the

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Kensington Stores, on account of the technical nature of the work; and for this reason the public cannot so easily judge of their value.

"From personal inspection our managers report that they are satisfied that the business is a sound and lucrative one." We remarked in a Note on July 4th, that the question is merely one of competition with the reliable products of the well-established manufactures of this country. We believe that okonite is a useful material; but, even if it had swept away and utterly superseded the use of "underwriters' wire" in America, it would not necessarily compete in this country with the almost forgotten "tape and tar," which was used eight or ten years ago. No evidence has yet been offered as to such decrease in cost, or increase in efficiency, as will ensure its reception in our markets.

As for personal inspection, that may be of some use in investigating an Automatic Machine or a Supply Store, but with okonite or Elmore copper we want actual experience. Speaking with reference to Elmore's Austro-Hungarian Patent Copper Depositing Company, the *Statist*, in a recent issue, pertinently remarks that "Before subsidiary Companies are floated in such quick succession, it would certainly have been desirable to have evidence that the parent Company was making satisfactory profits from the manufacture, and was evidencing commercial results, giving an adequate yield on the money invested. In other words, the public ought to have some proof that the purchase price of the patent rights is justified by actual results to the vendor; and proof ought to be afforded by the original vendor company, for here we have an intermediary vendor between the original patentee and the company which has the Austro-Hungarian patents. We have witnessed such disappointment from the formation of other subsidiary companies to work patents that we should very much regret to see the public rush to conclusions in this case without full investigation as to the merits."

It is probable that most of the shareholders of Woodhouse and Rawson (Limited) and of Woodhouse and Rawson United (Limited) can look after their own interests, and place their own interpretation on the report of the latter Company, which will be found in the present issue, without any assistance from the technical press. Electrical engineering and manufactures seem to be quite insignificant compared with their financial undertakings. Comments on their mode of conducting business may, therefore, be left to the financial journals, who appear to grasp the situation, and to offer some very pertinent observations thereon. The brief account which we give to-day of the extraordinary meeting of the old Company will be of interest to others than the shareholders.

The American Duty on Mica.—By the McKinley Bill a duty of 35 per cent. *ad valorem* is imposed on mica.

The Telephone in Spain.—Telephonic communication is about to be established between Madrid and the Royal Palace of La Granja, a distance of 100 miles.

Electric Traction in Berlin.—The Allgemeine Elektricitäts Gesellschaft are about to apply the Thomson-Houston-Huber system to the Wilmersdorf-Königgrätzerstrasse line.

Oswaldtwistle Local Board.—The Oswaldtwistle Local Board have agreed to the construction of an electric tramway through the township to Accrington on satisfactory terms by arrangement with Mr. Chadwick, C.E.

Madrid.—The Spanish Postal and Telegraphic Administration has requested the Telephone Company of Madrid to carry out the contract entered into with the State in regard to placing its cables underground within the term of a year.

Birmingham.—A number of members of the South Staffords shire and East Worcestershire Institute of Mining Engineer-paid a visit on Thursday last week to the electric-charging station of the Central Tramways Company at Bournbrook.

Gravesend.—The Town Council, after many discussions in committee, have at last come to a decision on the question of electric lighting, and have passed a resolution in favour of the requisite steps being taken for securing an electric lighting Order.

Experiments with the Electric Arc.—Experiments with the electric arc, when set up between carbon points in dry oxygen, show that there is a formation of a mixture of carbonic oxide and oxygen, and that the carbon is not at once burned to carbonic acid.

London Chamber of Commerce.—Among the Companies, firms and gentlemen elected members of the London Chamber of Commerce at the last Council meeting were Elmore's Patent Copper Depositing Company, Messrs. J. D. F. Andrews and Co., and Mr. Geo. Offer.

Edinburgh.—At a meeting of the Town Council on Tuesday, it was resolved, on the motion of the Lord Provost, to make application for a Provisional Order under the Electric Lighting Acts, and that the application by four companies for consent to apply for Provisional Orders should be refused.

New Cable.—The India Rubber, Gutta Percha, and Telegraph Works Company have just completed the shipment of about 2,000 miles of telegraph cable for the Central and South American Telegraph Company, to be laid from Lima to Iquique, and thence to Valparaiso, on the West Coast of South America.

The Telephone in Warfare.—According to *La Lumière Electrique*, a "telephonic bonnet" has just been adopted in the Italian garrison artillery, the idea being that the gun detachment commanders should array themselves in this headgar so as to be in constant communication with the officer commanding the battery or fort.

Barnsley.—On Tuesday last the Barnsley Town Council sat for nearly four hours discussing the desirability of carrying out the tender of the Westinghouse Electric Company, which has already been endorsed by a large majority of the Council. In the result, the Council decided by eleven votes to seven to go on with the matter.

Press Messages.—In connection with the meetings of the Church Congress at Hull last week it may be interesting to note that no fewer than 350,000 words of press messages were telegraphed during the four days from the Hull Post Office. The largest number of words transmitted on any one evening reached the figure of 100,000.

The Lighting of the City.—At the last meeting of the Commissioners of Sewers, the recommendation of the Streets Committee, that advertisements should be issued inviting tenders for lighting the western district of the City by electricity on similar conditions to those arranged for the east and central districts, was adopted without discussion.

O. S. A. Annual Dinner.—The sixth annual dinner of the Old Students' Association of the City and Guilds of London Institute will be held at the Holborn Restaurant on Friday, October 17th, at 7 p.m. Tickets, price 4s. 6d. each, may be obtained from the Secretary, 14, Garfield-road, Lavender Hill Mr. W. B. Esson is the President of the Association for the ensuing session.

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Leeds.—At a special meeting of the County Council, held on Monday, to consider the report of the Electric Lighting Committee of the Corporation, it was decided, by 35 votes to 4, that it was not desirable for the Corporation itself to supply electricity for public and private lighting purposes, as, in the opinion of the Council, such a supply could be advantageously provided by private enterprise.

Personal.— Last week the electrical engineering students of Messrs. Immisch and Co., Kentish Town, presented a piece of silver plate as a token of their esteem to Mr. Charles Francis Quicke, late chief engineer and works manager, on his relinquishing that post after eight years' connection with the firm. The workmen and staff also presented on their own behalf a massive silver spirit case and an inlaid cabinet.

Reduction of Telephone Rentals.—The Directors of the National Telephone Company have decided to reduce the telephone rentals at Leeds from £15 to £10 per annum; and they are further considering the question of giving special advantages to their subscribers for trunk line service. At Glasgow the rentals are to be reduced to £10 per annum for all subscribers within a radius of half a mile of the telephone exchange.

The Lane Fox Electrical Company.—This Company, finding that all their conciliatory efforts have failed, and that the merely nominal terms which they offered have been rejected, have issued writs on the Directors and Secretary of the Kensington and Knightsbridge Company, and on Mr. Crompton as their Consulting Engineer. The Lane Fox Company have retained Sir Richard Webster, Mr. J. F. Moulton, Q.C., and Mr. Graham.

The Yorkshire College.—The Marquis of Ripon presided, and presented the prizes at the Yorkshire College on Tuesday. Lord Ripon, in the course of his address, acknowledged the handsome manner in which the public had responded to the appeal for £40,000 for the formation of an additional building fund, £32,500 having already been raised. In conclusion, he counselled his audience not to forget that that College was not only a Technical College, but a University College.

The Copper Market.—The copper statistics for the month of September show that the stock in England and France and afloat thereto amounted, on September 30th, to 69,906 tons, compared with 69,959 tons at the end of August, and 72,533 tons at the end of July. The total supplies in England and France are stated at 10,187 tons, against 9,393 tons at the end of August; while the deliveries during September were 10,240 tons, compared with 11,967 tons during the previous month.

American Electrical Units.—At the first meeting of the American Institute of Electrical Engineers for the season 1890-91, Prof. F. B. Crocker moved that the unit of self-induction be hereafter known as the "henry," after Prof. Joseph Henry, instead of as the "quadrant," the term adopted at the last Electrical Congress at Paris. The name was unanimously adopted with applause. A committee was then appointed to consider what would be the proper size of the unit, and to report at the next meeting.

Gordon Technical College (Geelong).—We have received a copy of the annual report of this institution, which has now been in existence for over five years. The only class of an electrical character is the one in which instruction is given in telegraphy. The lecture-room is fitted up exactly like a modern telegraph office, and there is every facility for students to acquire a thorough practical knowledge of telegraphy. Instruction is also given in building construction, mechanical drawing and machine construction, chemistry, photography, and general physics.

The Post Office Telegraphists.—On Saturday afternoon last the Postmaster-General notified to the staff of the General Post Office that he had, in continuation of the memorandum of July 14 last, with the sanction of the Lords of the Treasury, converted 43 of the senior class appointments into second-class assistant superintendents, at a salary commencing at £200 per annum, and increasing to £260, the *minimum* of the senior class to be £160. He had also converted some of the female first-class appointments into a higher class.

The Barking Electric Tramway.—A deputation from the Glasgow Corporation recently visited the General Electric Power and Traction Company's electric cars and installation on the Barking-road section of the North Metropolitan Tramways Company's system. At the meeting of the Glasgow Town Council on Tuesday last the Committee on Tramways recommended that application should be made to Parliament in the ensuing Session for authority to use electric and other power on the Corporation tram lines. The recommendation was unanimously approved of.

The Weight of a Cubic Inch of Water.—A re-determination of the true weight of a cubic inch of distilled water has recently been made at the Standards Department of the Board of Trade. A platinised hollow bronze cylinder, whose volume was 572·803651 inches, and whose weight in air was 183676·066 grains, was used together with a quartz cylinder and a brass sphere. After this magnificent parade of accuracy, the results differ in the fifth significant figure, and the conclusion is that the weight of the cubic inch of water at 62° Fahr. appears to be $252{\cdot}286 \pm 0{\cdot}002$ grains.

The School of Electrical Engineering and Submarine Telegraphy.—As the result of the examinations, recently held at the above School, we are informed that the following gentlemen have now obtained the Vellum Certificate of the School:—(*a*) In Electric Lighting and Power Transmission: Messrs. Claypoole, Garré, Gillies, Lawrence, Phillips, Roussel, and Waring. The examinations in these subjects were conducted by Mr. Gisbert Kapp, and included a "vivâ voce" and Practical Examination. (*b*) In Telegraphy and Telephony: Messrs. Lawrence (above named) and Salmony. This examination was conducted by Mr. H. R. Kempe.

The Rating of Telephone Poles.—An important rating case affecting telephone companies was heard at Totnes last week. The Western Counties and South Wales Telephone Company appealed against a rating of £25 made by the overseers of the parish of Kingswear upon the Company's poles and wires in the parish. It was urged by the Company that it was not deriving any income from the parish of Kingswear, as there was no exchange or call office in the parish, and in other places the Company's poles and wires were only rated at the nominal value of 5s. per mile. After hearing further arguments, the Assessment Committee decided to reduce the rateable value from £25 per annum to the nominal sum of £1 per annum.

The New York Subway Rentals.—According to the report of the Engineer of the Board of Electrical Control, the present schedule of rentals charged by the Subway Company is as follows: For 4-inch ducts, £250 per mile per annum; for 3-inch ducts, £200 per mile per annum; for 2½-inch ducts, £170 per mile per annum; for 2-inch ducts, £140 per mile per annum; for 1½-inch ducts, £110 per mile per annum; for 1¼-inch ducts, £100 per mile per annum. For distribution ducts, 1 to 4in., £200 per annum. The high-tension electric light companies generally occupy ducts of 3in. diameter. Up to January 1, 1890, 501 miles of telegraph and telephone ducts, and 515 miles of electric light and power ducts had been constructed, making a total of 1,016 miles of ducts.

Test of a Submarine Electric Light Cable.—The *India Rubber World* says the experiment was recently tried of sending an alternating current of 1,000 volts pressure through the submarine cable which connects the electrically lighted buoy off Robbin's Reef, New York harbour. The experiment was made to see if the cable would stand the stress without breaking down or developing a fault, and the result was entirely successful as far as the cable was concerned. There was no leakage and no injury to the cable. This cable is insulated with gutta percha, and was made by the Bishop Gutta Percha Company. The same company also manufactured the cables which carry current for lighting the six buoys in Gedneys Channel.

New Books.—Amongst the new scientific books about to be published are:—"The Principles of Chemistry," by D. Mendeléeff, translated by George Kamensky, of the Imperial Mint, St. Petersburg, and edited by A. J. Greenaway (Messrs

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Longmans and Co.). "A Popular Treatise on Electricity and Magnetism," by Amédée Guillemin, translated and edited, with additions and notes, by Prof. S. P. Thompson; "Popular Lectures and Addresses," by Sir William Thomson, Vol. III. (Messrs. Macmillan and Co.). "A Treatise on Electricity and Magnetism," by J. Clerk Maxwell, new edition; "An Introduction to the Mathematics of Electricity," by W. T. A. Emtage (Clarendon Press). "A Text-Book of Electro-Metallurgy," by W. G. Macmillan; the complete volume of Prof. Jamieson's elementary manual of "Magnetism and Electricity" (Messrs. Charles Griffin and Co.). Messrs. Whittaker also announce a new and revised edition of Mr. Gisbert Kapp's "Electric Transmission of Energy," and a book on "Electro-Motors," by S. R. Bottone.

Exeter.—A special meeting of the City Council was held on Monday, to consider the application of the Exeter Electric Light Company and the report of the Special Committee on Electric Lighting. Mr. Andrew said he was unable to agree to the resolution of the Special Committee, who had resolved that, in their opinion, the Council should apply for a Provisional Order, and that the consent of the Council should not be given to the granting of an order to the Electric Lighting Company. He moved:—"That inasmuch as any monopoly in the supply of electric lighting is rendered impossible by the Acts of 1882 and 1888, which also safeguard the interests of the citizens in other directions, it is not desirable that the Council should take steps to obtain a Provisional Order until it is ascertained what arrangements can be made with the existing Electric Lighting Company for an optional purchase by the Council of their works within a shorter specified period than 42 years." The amendment was carried by 28 to 13 votes; and it was resolved to call a special meeting of the Council a month hence, to again consider the question of giving assent to the Electric Lighting Company's proposed order.

Electric Traction in Budapest.—The Budapest Electric Railway, which was built by Messrs. Siemens and Halske on the underground-conductor system, has proved a decided commercial success. Some 20 cars run on the line, the length of which is 7·9 kilometres. The line passes through the most fashionable streets of the town. During the month of April, 337,200 passengers were carried, being at the rate of 42,684 per kilometre of line, and 16,860 per car. The horse lines in the same town, which have a total length of 45·6 kilometres, and 329 cars, carried in the same month only 33,074 passengers per kilometre, and 4,854 per car. The earnings for the month were, for each electric car, £102; for each horse-car, £37. Since the date of this return, it is said that the differences in favour of the electric lines have been still further increased. The greater speed attained by the electric cars (11 miles per hour, as against 5) is no doubt responsible to a great extent for this flourishing state of affairs. The Town Council has also recently given permission for the building of a small electric line on the Zipernowsky single-track system. An experimental length of 3 kilometres, from Messrs. Ganz's factory to Steinbruch, is at present being laid down.

Special Edison Lamps for Series Working.—The American Edison Lamp Works are now turning out a large number of small incandescent lamps for burning in series on 110-volt circuits. These "small-series burning lamps" are made in candle-powers of 1 to 4 candles, and they require about 14 volts. Their efficiencies vary from 3 to 5 watts per candle. Some tests to determine the best efficiency to give these lamps are now being made at the Edison factory. Another lamp now being manufactured is designed for use on power circuits, and particularly for use on 500-volt street railway circuits. The lamps are made to give 16 candle-power. The voltage ranges from 95 to 100 volts, and the currents from ·60 to ·75 amperes. In designing the "railway" lamp, it was thought best to give it a stouter carbon such as would not be so easily injured by the mechanical strain to which the carbon of the lamps are subjected. Very high efficiency is not to be desired in these lamps on account of the constant variation in the E.M.F. on the circuit. The efficiency of the lamp as determined on is about four watts per candle. The voltage on the circuit can fall considerably below the 500 volt limit, as it is constantly doing on the railway circuits, without bringing the lamps to a very low incandescence; also an increase in pressure of 10 per cent. will not cause the lamps to break at an abnormal rate.

The Middleman in Electric Lighting.—Under this title an occasional correspondent writing to *The Times* reviews the question of the transference of the powers and liabilities attached to electric lighting orders obtained by local authorities. He points out, as we have frequently done in these columns, that the functions of local authorities will be those of middlemen, of prejudicially interested middlemen, in many cases with the power and the motive to farm out their order on terms more onerous than those conceded by the Electric Lighting Act of 1888; traders not in electric lighting but in an Act of Parliament. They would rather not take the risks, but the profits, should there be any; these they would like to pocket at an earlier date than the Act provides for. Can this be done without checking, without arresting altogether, it may be, the further development of electric lighting? Now, the amount that would be refunded to the Company by the sale of the undertaking on such terms as these must of necessity represent but an infinitesimal part of the total capital that would have been spent in the building up of the business. A sinking fund, large in proportion to the shortness of the tenure, must be set aside out of income for the redemption of capital. The larger the sinking fund the higher must the charge be for electricity. The conclusion is inevitable that to what extent soever you may succeed in reducing the tenure of supply authorised by the Act, to just that extent you handicap the electric light; to just that extent you lessen its attractiveness for the prudent investor. In the Lords' Select Committee of 1886, Lord Ashford and Lord Balfour of Burleigh made several efforts to exclude gas-owning Corporations from those local authorities whose consent was to be necessary to the granting of a provisional order to private undertakers. Their efforts were, unhappily, not successful. And the result has been to render the Act a dead letter in the case of all towns so governed. The truth is too often lost sight of, that private capital will not take the risk of developing a new enterprise for the simple good of the community. It is very selfish, but then the millennium has not dawned yet.

The Copenhagen Specification.—The specification for the central station at Copenhagen is a document of very uneven character, and is prefaced by a note to the effect that the Magistracy does not take upon itself any responsibility for the translation. "The first plant is to be arranged for a supply of about 14,000 contemporaneously burning incandescent lamps of 16 English candle-power each." A security of 10 per cent. of the contract sum is demanded, and a fine of one-third per cent. of the value of the work not completed, "for every beginning week which expires before the time specified." There are to be seven boilers of the Babcock-Wilcox, Steinmüller or similar make, to work at ten atmospheres, each giving 7,700lb. of steam per hour, with a maximum moisture of two per cent. Tests of the fuel, boilers, and dryness of steam are described. Four steam engines are to be provided, one of 100 effective horse-power, one of 300, two of 500, and space is to be left for two of 1,000 horse-power. They are to be compound receiver, condensing, hammer type, cranks at right angles, and coupled direct to the dynamos. The speed of the engines to be 150 and 125 respectively, and a variation of not more than 1½ per cent. is to be allowed from full load to one-eighth load. A full specification of the engine is given, and consumption tests are described. The specification of the dynamos is considerably more vague than that of the "motorial part of the plant." "During motion they must be warmed but to a slight degree . . . without using uncommonly much oiling material." "The dynamos must be capable of changing the mechanic strength transferred from the engines to the shafts, into electric energie with as small loss as possible." A switch-board for 20,000 simultaneously-burning 16 candle-power lamps, and accumulators "that without over-exertion by themselves are able to furnish 1,000 lamps" for eight hours, are to be provided. The three-wire system is to be employed in distributing, and the pressure is to be such that two arc lamps in series can burn steadily, but it must not exceed 110 volts. A fall of 1·4 volt is allowed on a pair of distribution mains at full load, and 14 volts on the feeders.

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MAGNETISM IN IRON AND OTHER METALS.*—XXXII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 579.*)

§ 118. Hysteresis in the Relation of Magnetic Susceptibility to Temperature.—Although no hysteresis appears in the experiments which have just been described, the magnetic condition depending, apparently, only upon the actual temperature and not upon past temperatures, it is still possible to experiment under conditions which show hysteresis in the relation of magnetic quality to temperature. Hysteresis of this kind is found when the range through which the temperature is varied is sufficiently wide to include the critical region, in which magnetic quality disappears during heating and reappears during cooling. The disappearance and reappearance do not occur at the same temperature. There are two critical temperatures: one is the point at which magnetic quality is lost during heating, and this is higher than the other, namely, the point at which magnetic quality is regained during cooling.

In ordinary iron and steel the difference between these two critical temperatures is not great—perhaps ten or twelve degrees in soft iron—and the direct measurement of it is a matter of some difficulty. That there is a difference, however, admits readily of easy experimental proof,† and may, indeed, be inferred from the phenomenon of recalescence. It is known that in recalescence there is, superposed upon the process of cooling, a real rise of temperature, and it is known that the change of magnetic state occurs simultaneously with the recalescence. If the change of constitution which then takes place depended upon the actual temperature alone, and not upon preceding temperatures, this rise would be impossible, for it would undo the very change which causes it. To make it possible the altered state of the material must be able to stand some elevation of temperature without changing back again; in other words, the change of constitution must show hysteresis with respect to temperature.

Osmond,‡ who has made a very full investigation of the temperatures at which perturbations take place during the processes of heating and cooling, finds that with electrolytically deposited iron there is a marked evolution of heat during cooling, about 855°C., and a marked absorption of heat during heating—about 867°C. There is no reason to doubt that it is at and about these temperatures that the changes from the non-magnetic to the magnetic state and from the magnetic to the non-magnetic state respectively occur.

In hard steel Osmond's experiments show a wider difference between the two critical temperatures. The principal evolution of heat during cooling occurs at 674°C., and the corresponding absorption of heat during heating occurs at 705°C. At any temperature between these limits we should expect to find this steel magnetic if the immediately preceding temperature had been lower, but non-magnetic if the immediately preceding temperature had been higher.

A much more remarkable difference of the same kind is found in what is called nickel-steel. Hopkinson has examined several alloys of iron and nickel, and has discovered, by direct magnetic tests, that in some of them the metal may retain either a magnetic or a non-magnetic condition throughout an extraordinarily wide range of temperature.‖ His results as to other physical properties of these alloys, as well as their magnetic properties, are of the highest interest.

§ 119. Hopkinson's Experiments with Nickel-Iron Alloys.—The samples were tested ballistically, in the form of rings, the temperature being inferred from the resistance of the secondary coil. A sample containing 4·7 per cent. of nickel and 0·22 per cent. of carbon, gave a magnetisation curve, at the temperature of the atmosphere, resembling the curves given by ordinary mild steel. When heated, the magnetic quality being tested by reversals of a magnetising force of 0·12 C.-G.-S., it was found to lose susceptibility between 750°C. and 800°C., and not to regain it on cooling until the temperature had fallen to 650°C. or 600°C. Fig. 90 shows the changes which took place during heating and cooling; it gives the induction B produced by reversing the force H of 0·12, in terms of the temperature. It will be seen that there is a clear range of about

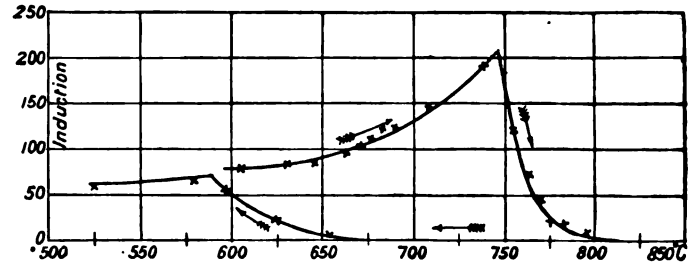

FIG. 90.—Steel with 4·7 per cent. Nickel. Magnetising Force 0·12.

150° within which the metal may exist in either of two states; in one state it is as susceptible as ordinary mild steel; in the other it is practically non-magnetisable, the permeability being, in fact, only about 1·4. Under stronger magnetising forces the magnetic quality appears and disappears at about the same two points. Further, an experiment in which the time rate of heating and of cooling were observed showed that the same two temperatures were marked by perturbations such as occur at the critical temperature in iron, the higher temperature being associated with an absorption of heat in the process of heating, and the lower temperature with an evolution of heat in the process of cooling. The heat which is liberated in cooling, at the temperature where magnetic quality returns, was found to be about 150 times the quantity which would raise the temperature of the piece by one degree.

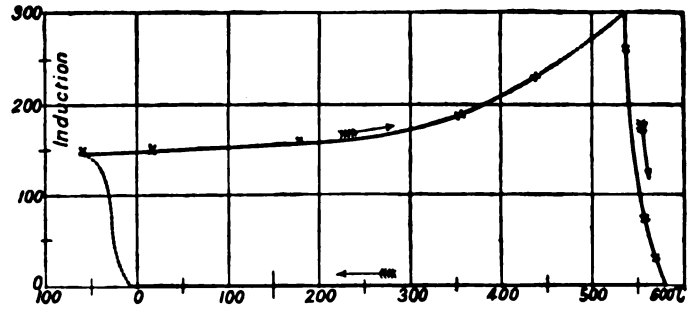

FIG. 91.—Steel with 25 per cent. Nickel. Magnetising Force 6·7.

Still more striking results were obtained with a specimen containing 25 per cent. of nickel. This was non-magnetisable at ordinary temperatures in its primitive state, but on being cooled in a freezing mixture it became magnetisable at a temperature a little below the freezing point. Rendered magnetisable in this way, it retained its magnetic quality on being warmed until the temperature rose to 580°C. At that temperature it became again non-magnetisable, and remained so on cooling down to the ordinary temperature of the air. Within a range of about 600 degrees this steel is capable of existing, quite stably, in either state. Figs. 91 and 92 show the induction B (produced by reversals of magnetic forces equal to 6·7 and 6·4 respectively) in terms of the temperature. In the non-magnetisable state the permeability is only 1·4; in the

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† A very pretty experiment, showing that the change of state which iron undergoes in passing a red heat occurs at different temperatures during heating and during cooling, has been described by Mr. Newall and by Mr. F. T. Trouton. A lamp flame, held under an iron wire which is in circuit with a galvanometer so that a short portion of this wire becomes red hot, is made to travel slowly under the wire, and it is found that a current appears in the galvanometer, the direction of the current depending on the direction in which the flame travels. The current is due to difference in thermo-electric quality between the red hot and the cold iron, and depends on the fact that on the side which is being heated the change of state is occurring at a higher temperature than on the side which is being cooled.

‡ Osmond "Transformations du fer et du carbone," *Mémorial de l'Artillerie de la Marine*, 1888.

‖ Hopkinson, *Proc.* Roy. Soc., December 12, 1889; January 23, 1890; May 1, 1890.

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magnetisable state the permeability resembles (but falls rather short of) that of hard nickel. The curve of magnetisation (at 13°C.) is copied in Fig. 93. Hopkinson has also shown that other physical properties of this alloy change along with its magnetic properties. The electrical conductivity is markedly different in the two states: at 0°C., for instance, the specific resistance is only 0·00052 if the substance has been brought into its magnetisable state by applying a freezing mixture, but is 0·00072 if it has been brought into the non-magnetisable state by previous heating above 600°C.

Equally pronounced differences are found with regard to extensibility and strength. In the non-magnetisable state this metal is comparatively soft; wires show an elongation of 30 per cent. or more before rupture, and break with a load of about 50 tons per square inch. In the magnetisable state it is much harder; there is only 7 or 8 per cent. of extension, and the strength is no less than 85 tons per square inch, or even more.

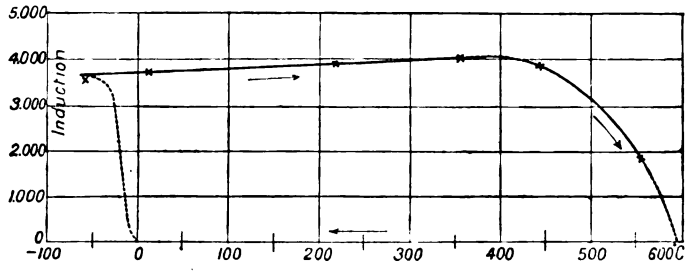

Fig. 92.—Steel with 25 per cent. Nickel. Magnetising Force 6·4.

"If," says Hopkinson, "this material could be produced at a lower cost these facts would have a very important bearing. As a mild steel the non-magnetisable material is very fine, having so high a breaking stress for so great an elongation at rupture. Suppose it were used for any purpose for which a mild steel is suitable on account of this considerable elongation at rupture: if exposed to a sharp frost its properties would be completely changed—it would become essentially a hard steel until it had actually been heated to a temperature of 600° C." It is interesting to notice that specimens of the non-magnetisable metal when broken in the testing machine pass into the magnetisable state; the change occurs along with the mechanical hardening which the metal suffers in being drawn out.

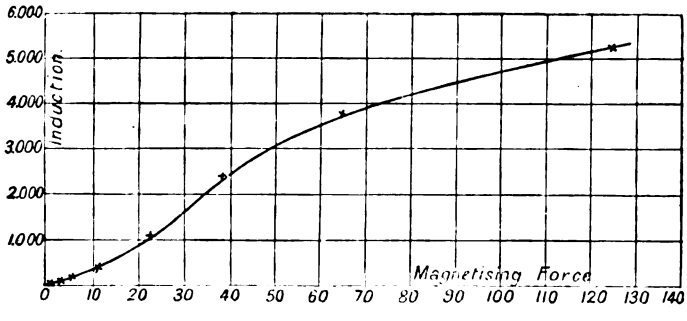

Fig. 93.—Steel with 25 per cent. Nickel. Curve of **B** and **H**.

This remarkable power of assuming one or other of two widely different physical states is less noticeable when the percentage of nickel in the alloy is further increased. Two other nickel iron alloys, containing respectively 30 per cent. and 33 per cent. of nickel, were found by Hopkinson to be much more permeable, and to show very much less hysteresis with respect to temperature in changing between the magnetisable and non-magnetisable states, and to change at a comparatively low temperature. Fig. 94 shows the results of magnetising the 33 per cent. sample with a force **H** of 1·0. The curves, which correspond to rising and falling temperatures, are not far apart, and the change takes place at temperatures lying near 200°C. In the 30 per cent. sample the critical temperatures are lower about 140°C. in heating and 125°C. in cooling). Finally, a sample containing 73 per cent. of nickel showed no material difference between the critical points for heating and cooling; its critical temperature was 600°C.

These observations make it not unlikely that a substance such as manganese steel, which is nearly non-magnetic in all conditions of temperature in which it has hitherto been tested, would become magnetic if the temperature were sufficiently

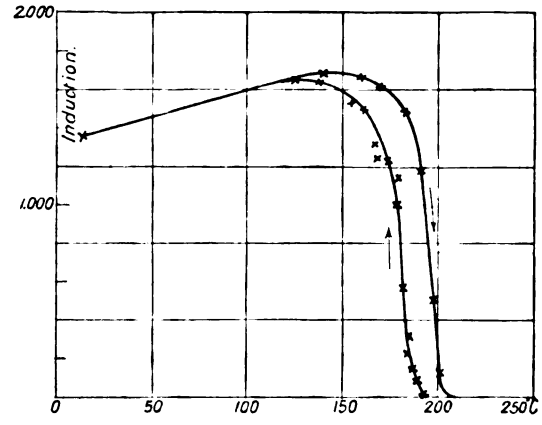

Fig. 94.—Steel with 33 per cent. Nickel. Magnetising Force 1·0.

lowered. And it is even possible that other metals than iron, nickel, and cobalt are non-magnetic only because all our dealings with them are at temperatures above a "critical point."

ON THE ELECTRO-DYNAMICS OF STATIONARY BODIES.*

BY H. HERTZ.

(Continued from page 581.)

Conservation of Energy.—Let us denote by S the electro-magnetic energy in a given volume τ, an element of whose surface is represented by $d w$. From (10) and (11), by multiplying the equations respectively by L, M, N, X, Y, Z, adding, and integrating throughout the volume considered, we deduce, in the same manner as in equation (4), the result

$$4\pi A \frac{dS}{dt} = -4\pi A \int (u X + v Y + w Z)\, d\tau + \int \begin{vmatrix} \cos(n,x) & \cos(n,y) & \cos(n,z) \\ X & Y & Z \\ L & M & N \end{vmatrix} dw \quad . \quad . \quad (23)$$

and if the volume τ includes a complete electro-magnetic system, so that the forces disappear at the surface, this equation reduces to

$$\frac{dS}{dt} = -\int (u X + v Y + w Z) d\tau. \quad . \quad . \quad . \quad (24)$$

This equation leads us to the conclusion that each unit of volume is a source of energy, and producing it at the rate denoted by $(u X + v Y + w Z)$. Experience tells us in what form this energy shows itself in particular cases. In the interior of good conductors the quantity of energy generated per unit volume in a unit of time, is, according to both theory and practice, given by either of the equivalent expressions

$$\lambda (X^2 + Y^2 + Z^2) = \frac{1}{\lambda} (u^2 + v^2 + w^2).$$

Where $\frac{1}{\lambda}$ is the specific resistance, X, Y, Z, are the components of the electromotive force, and u v and w the components of the electric current. These expressions are in perfect accordance with (24) since for such conductors we have $u = \lambda X$, $v = \lambda Y$, $w = \lambda Z$.

Again at the bounding surface of isotropic homogeneous bodies the quantity of energy produced in the separating layer per unit volume, per unit time, is given by the expression

$$u X' + v Y' + w Z'.$$

* An abstract of a paper published in the "Nachrichten von de Kœniglichen Gesellschaft, der Wissenschaften," for March, 1890; and reprinted in *La Lumière Électrique*, July, 1890.

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An integration extended from one side to the other of the separating layer shows that the rate of increase of energy per unit of separating surface is equal to

$$(u\cos(n,x)+v\cos(n,y)+w\cos(n,z))\,\phi_{12}$$

or proportional to the current of electricity across the surface. Experience shows that a similar expression holds true in practice. Its value may be positive or negative, and, according to circumstances an augmentation or diminution of energy may be denoted by it. If this energy takes the form of heat, it corresponds with the Pelter effect, and we call the electromotive force acting a thermo-electric one. If we have to consider the chemical energy as well as the heat energy, we call the electromotive force a chemical one.

Finally, let us consider a limited portion of the system, and calculate the rate at which the total energy is increased. This rate is given by the expression

$$\frac{dS}{dt}+\int(uX+vY+wZ)\,d\tau.$$

Since it must exceed the rate of increase of electro-magnetic energy by the quantity denoting the rate at which energy is being dissipated. By reference to (23) it is thus apparent that the variation of the energy accumulated within any space can be exactly calculated by supposing that the energy travels across the bounding surface in such a way that the energy current per unit of area of the bounding surface is equal to

$$\frac{1}{4\pi A}\begin{vmatrix}\cos(n,x) & \cos(n,y) & \cos(n,z)\\ X & Y & Z\\ L & M & N\end{vmatrix} \quad . \; . \; 25$$

Investigation of this expression shows that the energy current thus defined flows at right angles to the direction of both the electric and magnetic forces, and that its value is equal to the product of the two forces, multiplied by the sine of the angle between them and divided by $4\pi A$.

In discussing this hypothesis of an energy current, it must be noticed that the way in which the integral has been split up is quite arbitrary, and that the results to which it leads are not always probable. For example, when a magnet is placed near an electrified body, the energy in the neighbouring space must, according to this view, be continually in motion in closed cycles. It seems to me that, in the actual state of our knowledge, we must accept with caution the idea of the localisation of energy, and its motion from one point to another. No analogous principles have as yet been introduced into the study of rational mechanics.

(To be continued.)

ON THE AIR CONDENSERS OF THE BRITISH ASSOCIATION.*

(Continued from page 619.)

BY R. T. GLAZEBROOK (WITH A NOTE BY DR. A. MUIRHEAD).

It remains, then, to give an account of the experiments undertaken for the purpose of comparing mica or paraffin condensers, as ordinarily used with the air condensers, and of investigating some of the effects of absorption.

The two well-known methods of De Sauty and Sir William Thomson have both been employed.

The arrangements are shown in Figs. 5 and 6.

The first of these is not really suitable for use in cases in which there is absorption, though with care a fairly accurate measure of the instantaneous capacity can be found. The resistances, R_1, R_2, can always be arranged so that the effect of the charge rushing into the air condenser shows itself, as a sharp kick of the spot of light—to the left, say—followed by a slower deflection in the other direction due to the absorption charge soaking into the mica or paraffin. The resistance for which this sharp kick practically disappears is fairly definite, and from it the instantaneous capacity can be found, while an observation of the resulting kick due to the absorption enables us to calculate the increase of capacity which arises from that cause. This can be done in various ways; the simplest, perhaps, is to disconnect the condensers from the circuit, and replacing the mica condenser by a variable condenser of small capacity, observe the kick this produces in the galvanometer, when charged with the same battery. From this the capacity to which the absorption is equivalent can be approximately calculated.

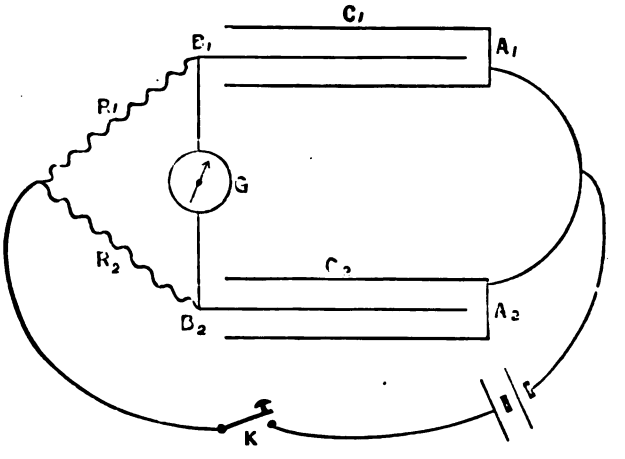

FIG. 5.—Comparison of Mica or Paraffin Condensers with Air Condensers (1st Method).

Thus, a condenser of about ·1 microfarad was compared with Dr. Muirhead's three condensers combined. Taking C_2, R_2, to refer to the air condenser, we had

$$C_2 = \cdot 009506$$
$$R_2 = 898650 \text{ ohms},$$

and with $R_1 = 89300$ there was a slight tremor to the left and a movement of 5 divisions to the right; on changing R_1 by 100 ohms, the change in the motion of the spot was marked.

This gives for the instantaneous capacity $C_1 = \cdot 09550$ the value found by the commutator at frequency 64 was ·09543 microfarads.

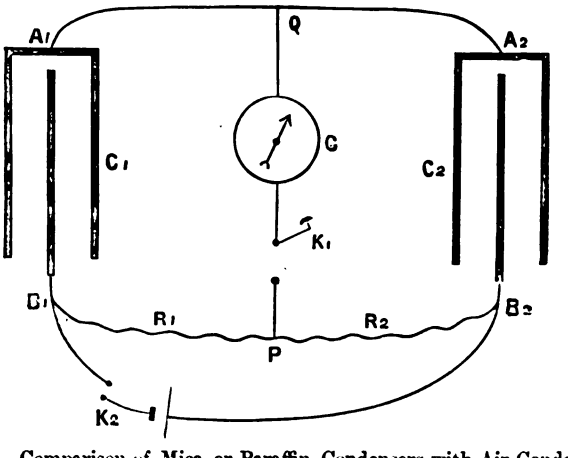

FIG. 6.—Comparison of Mica or Paraffin Condensers with Air Condensers (2nd Method).

To evaluate the 5 divisions, the air condenser was disconnected, and the mica condenser replaced by one of capacity ·001 microfarads; the kick observed was 4·8 divisions, while with ·002 microfarads it was 9 divisions, thus a kick of 5 divisions corresponds to about ·0011 microfarad capacity. Hence the capacity of the mica condenser, including the full effect of absorption, is ·0966 microfarads.

The second method, about to be described, in which the absorption effect is included, gave ·0965 microfarads.

Let us now consider the second method. The current from a battery flows through a large resistance, R_1+R_2, B_1 P B_2 (Fig. 6). One plate of each condenser is in contact with B_1 and

* Paper read before the British Association in Section A, Leeds, September, 1890, being an Appendix to the Report of the Committee on Electrical Standards.

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B_2 respectively, let V_1, V_2 be the potentials at these points. The other plates, A_1, A_2, are insulated and connected together and to the galvanometer G the other pole of the galvanometer can be connected to P, through the insulated key K_1. The galvanometer can be replaced by an electrometer. Let R_1 be the resistance, P_1 B, R_2 the resistance, P B_2. Suppose the point, P, be put to earth, the rest of the circuit being insulated. Then if C_1, C_2, be the capacities it is easy to see that there will be no current through the galvanometer on making the key K_1, if $C_1 R_1 = C_2 R_2$.

Now, in the case of a mica or paraffin condenser the capacity is a function of the immediate past history of the condenser, and different values will be found for the R_1, R_2, according to the time the charging has lasted. Dr. Muirhead, however, who uses the method largely, has shown how to obtain the instantaneous capacity from the observations. His method is described in the following extract from a letter to myself.* In the method as described, one pole of the battery is to earth instead of the point P of Fig. 6.

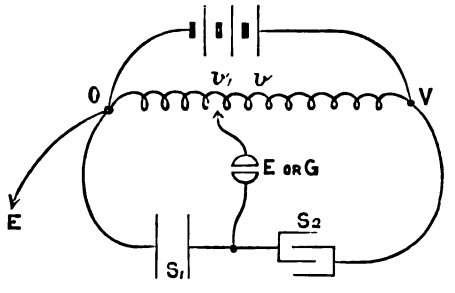

Fig. 7.—Comparison of Condensers (Dr. Muirhead's Method).

Dr. Muirhead writes:—"I have ·05 microfarad nearly in all condensers, and a series of mica condensers of ·1, ·2, ·3, ·331 (original one-third) and ·498 (original ·5) mf. capacity, all enclosed in a double air-tight box to keep the temperature as uniform as possible. The capacity of these standards is determined periodically by both the tuning-fork method (using a revolving commutator instead of the tuning fork), and by the ballistic galvanometer method. One can make comparisons of these condensers among themselves and with other condensers by the method I adopt to an accuracy of 4 in 10,000. The temperature coefficient of shellacked mica condensers is about ·018 per degree centigrade and of paraffined mica ·034 per cent.

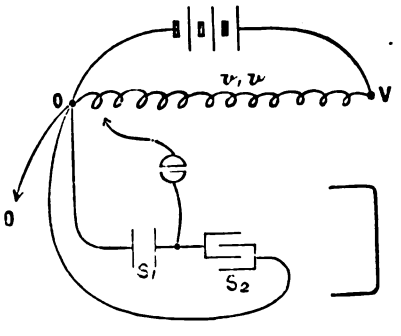

Fig. 8.—Comparison of Condensers (Dr. Muirhead's Method).

Let S_1 (Fig. 7) be the capacity of the air condensers,
" S_2 " " condenser to be compared with air condensers.

After making battery contact, supposing the charging of the condensers to be instantaneous and the absorption *nil*, then we have

$$v S_1 = (V - v) S_2$$

where v is the potential of the junction of the two condensers. Should there be any delay in obtaining the balance, the position of r on the slides will vary—say to v_1—then the charges on the two condensers will be

$$v_1 S_1 \text{ and } (V - v_1)(S_2 + \sigma)$$

respectively where σ is the apparent increase of capacity of S_2 due to absorption or soaking in of charge. On disconnecting the armature of S_2 from the slides and putting it to O (Fig. 8), or earth, the potential falls from V to O, and immediately afterwards the potential of the junction of the two condensers becomes, say, v_2, so that

$$S_1 v_1 + S_2 (v_1 - V) = (S_1 + S_2) v_2.$$

Hence
$$v_1 (S_1 + S_2) - V S_2 = (S_1 + S_2) v_2.$$

or
$$S_2 = S_1 \cdot \frac{v_1 - v_2}{V - (v_1 - v_2)}.$$

V and v_1 are known, and v_2 is indicated at once on an electrometer, or when a galvanometer is used it can be measured quickly, thus:—As soon as v_1 has been observed, break the galvanometer contact and move the index of the slides down to O, then directly after bringing the armature of S_2 from the full potential of the slides to zero, close the galvanometer circuit and observe the throw, a, which is a measure of v_2, the potential of the junction of the two condensers."

In my own experiments, which were made after consultation with Dr. Muirhead, I adopted a method practically the same as his; but before describing it it will be better to consider rather more the effects of absorption. Let us suppose, at first, that the leakage from either condenser is inappreciable. If there be no absorption, each condenser is charged to its full potential practically instantaneously, and it does not matter when or in what order the keys, K_1 K_2, are put down; the position of P on the slide is not affected.

Suppose, now, that C_1 shows absorption, the capacity increases with the time of charging. We can get the instantaneous capacity by depressing—first, the key K_1 and then K_2; but in this case we are troubled with the effect of the slow after charging as in the other method. Still the resistance, for which the kick due to the initial charging disappears, is, with the condensers I employed, fairly marked, and a value for the instantaneous capacity can be thus fairly accurately obtained.

If, now, K_2 be made for 1 second and then K_1 depressed, a different position will be found for P. With this interval of charge the apparent capacity differs appreciably from its instantaneous value, and the after effects of the absorption can still be observed. The same is true for intervals of 2, 3, or 4 seconds, the value obtained for the capacity increases, and the after effect is still noticeable; but with the condensers and battery I used, if the time of charging was prolonged to 5 seconds, the after effect was inappreciable, and the position of P on the slide, and hence the apparent value of the capacity, were hardly affected by further increasing the time of charge. In the experiments on a cable recorded in Dr. Muirhead's Paper, already referred to, the absorption effects continue much longer. In the observations recorded below, then, unless the contrary is stated, the key, K_2, was held down for 5 seconds, and then, K_1 being depressed, the position of P determined, for which the galvanometer remained unaffected. The value of the capacity deduced, then, is the full capacity for the potential to which the condenser is charged. It is, of course, possible, though further experiments would be wanted to prove it, that the full effect of absorption is not merely to increase by a definite amount, independent of the potential, the apparent instantaneous capacity, but that the increase may depend on the potential to which in each case the condenser is being charged. It will, of course, depend on the purposes for which the condenser is to be used whether the instantaneous capacity or the full capacity is required; and it probably will be best, when issuing certificates, to state both the instantaneous capacity and the maximum increase due to absorption—mentioning at the same time the potential used in the experiments for determining this correction, and also the time of charging in which this maximum increase is practically attained.

The method I employed in determining the correction due to absorption was the following:—Suppose the plates, A_1 A_2, to be at potential zero and uncharged. Make the battery key, K_2, and after keeping it made for some little time break it again. If there be no absorption A_1 and A_2 will still be at zero potential and uncharged; but let there be absorption in one of the two, A_1, and let B_1 be the positive pole of the battery; then, while the battery is on, negative electricity is being

* See also *The Electrician*, Sept. 5, 1890.

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absorbed by the dielectric near A_1, and positive electricity is left free over the plates, A_1 A_2, and the wires connecting them. When the battery is broken the negative electricity begins to soak out, but the process takes time. Hence, if immediately on breaking the battery key, K_2, the galvanometer key, K_1, is made for an instant, there is a throw of the galvanometer needle indicating the passage to the earth of the positive set free by the absorption. If, after a time, the galvanometer key be again depressed, there is an equal throw in the opposite direction caused by the passage of the negative which has again soaked out of the condenser. The required correction is obtained from either of these throws.

For, let i be the current between B_1 and B_2; let C_1 be the instantaneous capacity of the one condenser and C_2 of the other; and let Q be the quantity of electricity absorbed. Then the quantity of negative electricity on the plate A_1 is $C_1 R_1 i + Q$, and the quantity of positive electricity on the plate A_2 is $C_2 R_2 i$, if we assume the potential of these plates to be still zero.

Therefore, $$C_1 R_1 i + Q = C_2 R_2 i$$

$$\therefore \frac{C_1}{C_2} = \frac{R_2}{R_1} - \frac{Q}{C_2 R_1 i}.$$

If E be the E.M.F. of the battery, then, neglecting the battery resistance,

$$i = \frac{E}{R_1 + R_2}$$

$$\therefore \frac{C_1}{C_2} = \frac{R_2}{R_1} - \frac{Q}{C_2 E}\left(1 + \frac{R_2}{R_1}\right).$$

Now, we have seen that with the galvanometer as I used it, if γ is the throw produced by the passage of a quantity Q, then $Q = \gamma \times 10^{-10}$.

The battery consisted of 36 small storage cells, which, when fully charged, had an E.M.F. of about 75 volts, so that

$$E = 75 \times 10^8.$$

Also, $$C_2 = \cdot 021 \text{ microfarads}$$
$$= 21 \times 10^{-18}.$$

Hence, with these numbers,

$$\frac{C_1}{C_2} = \frac{R_2}{R_1} - \frac{\gamma}{1575}\left(1 + \frac{R_2}{R_1}\right).$$

Or, writing it as a correction to C_1,

$$C_1 = \frac{C_2 R_2}{R_1} - \frac{\gamma}{75}\left(1 + \frac{R_2}{R_1}\right)10^{-18}.$$

Examples of the method of applying this correction will be given shortly.

It will be noticed that a leak in one of the condensers may be corrected for in the same way. For, suppose the mica condenser to leak, then a quantity of Q^1 of positive electricity passes through to the plate, A_1, while the battery current is on, and the condition that the galvanometer should not be deflected is,

$$C_2 R_2 i - C_1 R_1 i = Q^1,$$

the same equation as previously.

There will, however, be this difference: on depressing the key, K, after breaking the battery circuit, a positive charge will in both cases pass from A to B through the galvanometer; if this charge be due to absorption, there will, when the key is again depressed after an interval, be a current through the galvanometer in the opposite direction; while if the first charge be due entirely to a leak, there will be no effect when the key is the second time depressed. In practice, the leak and the absorption may exist together either in the same or different condensers. In the second case the leak will tend to produce opposite effects to those caused by the absorption; the quantity, Q^1, however, increases nearly in the ratio of the time of charging, while Q increases for the first few seconds, but soon reaches a maximum and then remains constant.

These considerations are illustrated by some experiments in which the condensers I. and II. were compared with various mica condensers. The battery key was in each case made for 30 seconds; it was then broken, and the galvanometer key was made for an instant, the resulting throw was the sum of those due to (1) the leak in the mica condenser (λ) say; (2) the absorption in that condenser (α) say; and (3) the leak in the air condenser, which produces an effect in the opposite direction $-\lambda^1$, say.

After about 30 seconds more the key was again depressed, the resulting throw is due to the absorbed electricity which has again leaked out, and this will give us $-\alpha$.

The following table gives the results; each observation entered is the mean of three or four.

Condenser compared with standard.	——	I.	II.
·05	$\lambda + \alpha - \lambda^1$	2·3	−7·3
	$-\alpha$	−3	−2·6
·1	$\lambda + \alpha - \lambda^1$	2·2	−9
	$-\alpha$	−3	−3
·1	$\lambda + \alpha - \lambda^1$	2·2	−7
	$-\alpha$	−2·2	−3·5
·5	$\gamma + \alpha - \lambda^1$	3·3	−4
	$-\alpha$	−3·3	−2·5
	$\lambda + \alpha - \lambda^1$	4	−3·2
	$-\alpha$	−5	−5·7

If we take the comparisons with condenser I. first, it appears that throughout $\lambda - \lambda^1$ is small. For the ·05 and ·1 microfarad it may be about −·5 divisions, while α is about 3 divisions; for the ·5 microfarad, α is rather larger being about 3·3 and $\lambda - \lambda^1$ is zero, while for the 1 microfarad α the absorption effect is distinctly larger, being 5 divisions, and $\lambda - \lambda^1$ is about −1. All this is, of course, quite consistent with the fact that condenser I. and the mica condensers insulate well while there is absorption by the mica.

When, however, we come to the condenser II. the results are quite different. While the absorption effects are comparable, as, of course, they ought to be, with those obtained in the comparison with I. the leakage effects are very large.

The values of $\lambda - \lambda^1$ in order are as follows: −9, −12, −10·5, −6·5, −8. Now we know that the mica condenser shows very little leak effect, the above leaks are therefore almost entirely in the air condenser II. If we suppose the total leak to be proportional to the time, then for the 5 second charges used in the experiments the corresponding values of γ in the corrections to be introduced for leakage will be one-sixth of the above, and thus we get the following results:—

Condensers.	Value of γ.	Correction to capacity in microfarads for the leak.
·05	1·5	·00007
·1	2	·00016
·5	1	·0003
1·0	1	·0007

It is clear that the corrections are in all cases small, being not much over 1 in 1,000, but they serve to illustrate the method. The above corrections are only those for the leak, the correction for absorption could be found in the same way.

With a view to testing the method in a case in which a leak only existed without absorption, a number of comparisons of I. and II. were made.

In these experiments the resistance with I. was 296,240. The resistances with II. and the deflection due to the leak obtained by breaking the battery and then making the galvanometer, are given below together with the ratio of the two capacities corrected for the leak.

Interval between battery and galvanometer contacts.	Resistance.	Leak in scale divisions.	$\frac{R_1}{R_2}$	Correction.	$\frac{C_2}{C_1}$
0″	275,980	0	1·0734	0	1·0734
5″	275,180	2·5	1·0765	−·0032	1·0733
30″	271,380	14·5	1·0916	−·0184	1·0732
60″	267,180	22·5	1·1088	−·0286	1·0802
5″	91,370	5	4·3223	·0168	4·3391
30″	92,670	22	4·2617	·0743	4·3360
60″	94,170	42	4·1938	·1415	4·3353

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The last three lines of the table give the results of a series of comparisons between II., which had a leak, and a condenser of ·1 microfarad, which showed absorption. The resistance with II. was 394,930 ohms.

In the first four lines the corrections are negative, for the capacity of the leaky condenser is being found in terms of the standard. In the next three lines they are positive, for the ratio of the mica condenser to the leaky standard II. is being found.

A comparison of the fourth and sixth columns shows the results of the correction. In the fourth line it is clear that the correction is not large enough. This probably arises from the difficulty of making contact with the galvanometer circuit sufficiently soon after the battery is broken to ensure that the whole of the charge accumulated by the leak should pass through the galvanometer.

The leak correction was also tested with similar results by putting an artificial leak in I.

We will now give some specimens of the observations made to compare I. with a mica condenser in order to show the accuracy attained. Condenser I. compared with ·1 microfarad; resistance with I., 493,560 ohms; resistance with ·1 microfarad, 105,800 + a; variable resistance given below.

In the table in which the effect of the galvanometer is shown by the letters R, L, in the last column, R means there was a deflection to the right, L to the left.

Interval between galvanometer and battery contact.	Variable resistance to be added above.	Effect on galvanometer.
5″	700	R
	400	L
	500	Very small R
2″	400	L
	700	R
	600	L
0″	1,200	L
	1,300	Tremor L, then swing to R
	1,400	R

Thus in this case the effect of an alteration of 100 in the resistance, *i.e.*, one one-thousandth of the whole, is very marked, and we may take the following values for the resistance:—

5″ interval	105,800 + 500
2″ „	105,800 + 650
0″ „	105,800 + 1,300

Other series of observations showed that the resistance for 10 seconds interval was the same as for 5 seconds; if the interval was prolonged to 30 seconds a very small increase in capacity was noticeable. Thus the effect of absorption is to increase the capacity of the ·1 microfarad by about 8 in 1,000, or ·008 of the whole, of this ·0065 shows itself in the first 2 seconds of charging, and ·0015 afterwards, the increase after 5 seconds, if any, being extremely small.

When comparing I. with ·5 microfarad the resistances used were 592,290 and 24,910 respectively. In this case an alteration in the latter resistance of 10 ohms, or one two thousand five hundredths, was easily seen. The following are the results:—

Interval.	Resistance.
10″	24,900
5″	24,900
2″	24,930
0″	25,060

Showing again that the absorption effect disappears after 5 seconds, and that the effect of absorption in 2 seconds is about ·0052, and in 5 seconds about ·0064 of the whole capacity.

When comparing with 1 microfarad, the resistances were 592,290 and 12,580, the last number being accurate to about 5 ohms, or about the same proportion as before.

The results of the various observations are given in the following table, the observations made with II. have been corrected for the leak as already explained.

Table *giving the Capacities of certain Mica Condensers as compared with the Air Condensers.*

Date.	Value from I.	Value from II.	Value found by commutator at frequency 64.
Aug. 19	·04934	·04938	
„ 23	·04934	·04936	·04867
June 17	·09772	·09780	—
Aug. 14	·09751	—	·09638
„ 18	·09773	·09786	—
„ 21	·09773	·09781	—
„ 18 (M)	·5005	·5008	—
„ 18 (A)	·5007	·5009	—
„ 21	·5006	·5010	—
„ 18	·9910	·9912	—
„ 21	·9913	·9912	—

It will be noticed that, for either condenser I. or II., the results are in very close accordance; with the exception of one observation, on August 14th, the differences are barely as great as 1 in 5,000, and the method is clearly capable of giving the value of a mica condenser in terms of the air condenser, to this accuracy.

The reason for the low result on August 14th is to be found in the fact that, on that day, the leak in I. was considerable, being, as we have seen, over 1 per cent. per minute. Full observations for the correction were not taken; it would, however, amount to about ·0002, judged by the correction required to observations on II., when leaking at a similar rate.

The results from II. are equally consistent among themselves, but all slightly greater than those from I. This would indicate that the correction applied for the leak in II. is rather too large.

The capacities given in the table are those found with a five seconds interval, by which time, as we have seen, the absorption in the mica condenser used is practically complete. We have already discussed the method of determining the instantaneous capacity, and a table of the corresponding values could easily be given.

For our present purpose it is hardly necessary to do this, and indeed for many purposes for which condensers are employed a knowledge of the full capacity is more useful than one of the instantaneous one. In the last column the values of the capacities found by the commutator are given; the differences in both cases amount to about 1·3 per cent. of the capacity.

During the forthcoming year condenser II. will be again set up and tested, and the permanent arrangements for rapidly comparing condensers and for issuing certificates will, I hope, be completed.

ALTERNATING VERSUS CONTINUOUS CURRENTS IN RELATION TO THE HUMAN BODY.*

By H. Newman Lawrence, M.I.E.E., and Arthur Harries, M.D.

The present Paper is supplementary to a preliminary Paper on the same subject read before the Institution of Electrical Engineers on 27th March, 1890.† In that Paper it was stated (*Society Journal*, Vol. LXXXVI., 1890) that "Our experiments have not been made with the powerful currents dealt with in electric lighting and distribution of power;" and this admission, together with the difficulties inseparable from the accurate measurement of alternating coil currents, are points in connection with our Paper which have given rise to much discussion in the electrical and other journals. In the present instance, however, we have endeavoured, as far as possible, to obviate criticism on these grounds:—(1.) By using currents directly from lighting circuits—both alternating and continuous. (2.) By using currents directly from a dynamo whose rate of alternation could be accurately ascertained. (3.) By using currents of high E.M.F. (4.) By using an instrument for the measurement of alternating currents whose accuracy at the reading of our former Paper was theoretically

* Paper read before the British Association in Section G, Leeds, September, 1890.

† See *Electrician*, April 4, 1890, p. 551.

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questioned by one or two speakers, but which has since been tested and proved to give correct readings by an eminent practical electrician (see *Society Journal*, Vol. LXXXVI., 1890), thus confirming the accuracy of the readings formerly recorded by the instrument, as well as those which are contained in our present Paper.

Another practical point to which special attention has been given in this Paper is that our experiments have been made chiefly with the skin in a state of nature, so that the conditions of experiment as nearly as possible resemble those which might be expected to exist under accidental circumstances, that is to say, under circumstances when contact with conductors was unexpected, and therefore unprovided for. With so much brief preface, we proceed to give in detail the results of several series of observations made under the conditions explained at each step.

Resistance.

In dealing with the resistance of the human body many difficulties present themselves, and render it by no means easy to arrive at definite data thereon. The complicated structure of the body at once prohibits any attempt to regard it as an ordinary inanimate conductor. Several methods have been tried or suggested. The Wheatstone Bridge method, which we previously adopted, was shown to be inaccurate by Mr. Otto T. Bláthy, in the *Electrician* of April 25, 1890, and the unsatisfactory nature of comparisons made between resistance measurements taken with the E.M.F. of a few battery cells, and those likely to result from the use of an E.M.F. such as is common in light and power circuits, has been pointed out by several of our critics. We have therefore thought it best to obtain our resistance measurements by passing the current direct from a light circuit through two or more bodies in series, and then, by noting the current strength passed and the E.M.F. used to pass it, to calculate the resultant resistance.

For this purpose we used in the first case dynamo-generated continuous current taken from the lamp leads at the Institute of Medical Electricity, which is supplied by the St. James's and Pall Mall Electric Light Company. Having disconnected a lamp the voltage was tested, and found by a Cardew voltmeter to be 104. We then connected up two metal electrodes of 45 square centimetres area each, which could be grasped in the hand, putting in series therewith only a milliampere meter having 755 ohms resistance and a key. Two persons joined hands, and each grasped one of the electrodes with his free hand. Circuit was then completed, and the reading taken.

The results are set forth in the following tables :—

Table A.—*Resistance to Continuous Current.*

Group.	E.M.F. in volts.	Current strength in milliamperes.	Total resistance.	Resistance of milliampere meter in ohms.	Resultant resistance of each person.
*1	104	7·5	13,866	755	6,555
*2	,,	5·75	18,086	,,	8,666
*3	,,	7·25	14,345	,,	6,795
*4	,,	9.25	11,243	,,	5,244
*5	,,	9·5	10,947	,,	5,096
*6	,,	8·0	13,000	,,	6,122
*7	,,	10·0	10,400	,,	4,822

Average, 6,185 ohms.

* Two persons.

In the second case we used a dynamo-generated alternating current taken from a Siemens' dynamo at the School of Electrical Engineering, Hanover Square, which was kindly placed at our disposal by the managers (Mr. Wm. Lant Carpenter and Mons. Leon Drügman). The arrangements for connection were exactly the same as those described above for the continuous current, except that groups of four and five persons joined hands, instead of only two. The same Cardew voltmeter, the same milliampere meter, the same electrodes were used.

The voltage varied from 115 to 137, and the alternations from 60 to 75 per second.

Table B.—*Resistance to Alternating Currents.*

Group.	E.M.F. in volts.	Current strength in milliamperes	Total resistance.	Resistance of galvanometer.	Resultant resistance of each person.
1. 5 persons	115	4	28,750	755	5,599
2. ,,	120	5	24,000	,,	4,649
3. ,,	123	7	17,571	,,	3,363
4. ,,	124	7	17,714	,,	3,391
5. ,,	124	6	20,666	,,	3,982
6. 4 persons	123	8	15,375	,,	3,655
7. ,,	137	9·5	14,421	,,	3,416

Average, 4,008 ohms..

These observations show results widely differing from those obtained by other methods, and indicate that while under these conditions the resistance to the two forms of current more nearly approximate to one another, yet that to continuous current is still considerably greater than that to alternating. It is interesting to note that the average resistance to alternating current obtained by this method closely corresponds to that obtained by Mr. Bláthy, and mentioned in his letter above referred to. He makes it from 4,000 to 5,000 ohms, and our results show an average of 4,008 ohms. We may state then, in round figures, that we find the resistance of the human body, under the conditions named to continuous current, to be 1·5 times that to alternating current.

We next endeavoured to find how far variations of the contact area would affect the result, and obtained the following readings :—

Table C.—*Variations in Current due to Alterations in Contact Area, E.M.F. being Constant.*

(Continuous dynamo current at 104 volts.)

Total contact area in square centimetres.*	Current strength in milliamperes.				
	Sub. 1.	Sub. 2.	Sub. 3.	Sub. 4.	Average.
90·0	10·0	10·0	10·0	10·0	10·0
45·0	7·25	5·25	7·0	5·25	6·19
22·5	6·0	4·75	5·75	...	5·5
†9·0	5·75	3·25	4·0	...	4·3

* Two electrodes each having same area, one being grasped in each hand.
† Electrodes held by thumb and finger only.

From this it appears that, in round numbers, a reduction in the contact area of 50 per cent. reduces the current strength by 40 per cent., a reduction in the contact area of 75 per cent. reduces the current strength by 45 per cent., and a reduction in the contact area of 90 per cent. reduces the current strength by 60 per cent.

It is manifest that to arrive at anything like a definite law on the subject a great number of readings must be taken; but we think the above results form a useful indication of the important bearing contact area has in determining the seriousness or otherwise of accidents in light and power circuits.

Sensation.

In this part of our Paper we propose to compare the results obtained when electrodes connected respectively with dynamo-generated continuous currents and dynamo-generated alternating currents are brought into and kept in contact for an appreciable time with the human skin in a natural state; that is to say, in the state normal to the person experimented upon at the time of testing. In order that this series might be complete, it would possibly have been better to give barometric, thermometric, and hygrometric readings, of which we have taken many; but these data belong rather to a complicated side issue, and do not affect the main question to which this Paper must necessarily be confined, so we have considered it best to omit them altogether—taking it that the subjects experimented on were in an average condition of health at the time, and that the atmospheric conditions were more or less like those to be expected in a climate similar to that of England.

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The results are tabulated as follows:—

Table D.

Conditions.—Metal-handle electrodes grasped in the hands (surface area 45 square centimetres each), in connection with dynamo-generated continuous current, taken from lamp-lead as before mentioned (Table A.).
E.M.F. 104 volts, by Cardew's voltmeter.

Subject.	Discomfort point.	Fixation point.
	Milliamperes.	
1.....	18	not any.
2.....	15	not any.
3.....	20	not any.
4.....	22	not ony.
5.....	15	not any.
6.....	20	not any.
	Average, 18·3	

In each instance, burning sensation under the electrodes became unbearable after about 30 seconds; this was the only objectionable feature, though electrolytic action was sufficiently marked to induce slight blistering in two of the cases. We have to call special attention to the fact *that in no case was muscular fixation, or any sensation approximating thereto, reached with the continuous current*, nor have we at present any reason to suppose such a result possible.

Table E.

Conditions.—Metal-handle electrodes grasped in the hands (surface area 45 square centimetres each).
Alternating Current from Siemens' dynamo.
E.M.F. 110 volts, by Cardew's voltmeter.
Number of Alternations per Second, 23.

Subject.	Current strength.	
	Discomfort point.	Fixation point.
	Milliamperes.	Milliamperes.
1.....	3·0	6·0
2.....	3·5	7·25
3.....	4·5	6·5
4.....	3·5	8·5
5.....	4·0	7·25
	Average, 3·70	Average, 7·10

Table F.

Alternating Current from same dynamo as last table.
Electrodes as last table.
E.M.F. 85 volts.
Alternations per Second, 68.

Subjects as before.	Current strength.	
	Discomfort point.	Fixation point.
	Milliamperes.	Milliamperes.
1.....	3·5	6.0
2.....	4·5	8·75
3.....	3·75	8·0
4.....	4·75	8·75
5.....	4·25 not reached at	8·0
	Average, 4·15	Average, 7·90

In Table E. it will be observed that the average discomfort point is 3·7, the average point of muscular fixation 7·10. In Table F. the average discomfort point is 4·15, the average fixation point 7·90, the mean of the two sets being 3·9 for discomfort point, and 7·5 for fixation point.

We wish to differentiate clearly between what we have termed *discomfort point* in connection with both varieties of current, and that which we have called the point of muscular fixation, which we have only been able to discover in experiments with the alternating current. This is the more necessary because herein lies one of the great differences in the danger of accidental contact with the two systems respectively. To put it plainly, *we have found no point at which it is impossible to release personal contact with a continuous-current circuit, while it is easy with a comparatively low-current strength to find a limit beyond which it becomes a physical impossibility to disengage oneself from contact with the alternating-current circuit. A little consideration will show that this cannot be too strongly emphasised, for while with the one personal effort will suffice to release the sufferer, with the other the agency of a second person must be called into play before the dangerous action of the current can be stopped.* Many of the critics of our former Paper appear to have failed to recognise this most important distinction, and to have regarded muscular fixation as synonymous with discomfort-point.

Tables E. and F. were constructed from observations made on the same patients in the same order with the same machine, though with an interval of two days; in the first table the E.M.F. was greater (110 volts), and the rate of alternation less (23 per second) than in the second table, when the E.M.F. was 75 volts, while the alternations were 68 per second. In Table E. fixation needed nearly twice as much current strength as discomfort, and in Table F the same sort of relation obtains, though in the latter instance the alternations were just three times as frequent. During the discussion on the Paper at the Electrical Engineers on March 27th, Dr. Harries in his reply stated that "The more rapid the alternations the more nearly did the conditions resemble those present with continuous current *as regards sensation*." Putting aside for the moment the difference of E.M.F. in the two sets of experiments (25 volts) a comparison of Tables E. and F. will fully bear out this statement, for we find that both average discomfort point and average fixation points are higher, though the alternations are so much more frequent in Table F.

It may not be out of place here to note that observations made with a Wheatstone's transmitter in another series of experiments at about the same time showed that a higher rate of alternations with same E.M.F. and current strength reduced the sensation. It is conceivable and probable that nerve impulses travel as waves at a given average rate of speed (90ft. per second. Helmholtz). But sensations may follow one another so rapidly and so irregularly that one set of waves may impinge upon and modify the next preceding set, thus altering the total effect which would be produced upon cortical centres by a given number of sensations in a given time. Alternations may be so rapid and irregular that these conditions are present in such wise that the total effect of a series of shocks given at a certain rate of speed is less than the total effect of a similar number of shocks given at a lower rate of speed. And it is only in this way that we are able to account for the power to bear larger current strength at a high rate of alternation, *i.e.*, when the rapidity is over 50 or so per second.

Shock.

With continuous-current shocks (sudden make or break) from dynamo-generated continuous lighting circuit with a current strength of 10 to 20 milliamperes, the sensation was that of a sudden jerk, followed by feeling of heat at the points of contact with the electrodes, increasing until the sensation became unbearable. The make jerk was distinctly more marked and more unpleasant than the break jerk, though the latter was followed by an increase in the sensation of heat in the neighbourhood of the points of contact, the increase persisting for two or more seconds after contact was broken.

Shocks of alternating current, from Siemens' dynamo-generated alternating circuit, were also taken by the subjects concerned in Tables A., B., C., &c. A tingling sensation was felt, which rapidly increased to muscular contraction, becoming more and more unpleasant, and accompanied by a sensation of heat in the neighbourhood of the electrode, though not immediately under the site of contact, as in the case of the continuous current. It was noticed that the maximum effect was *not immediately* felt, an increase being apparent for one or two seconds, the hands being still in contact with the electrodes. This effect was most apparent with small currents (two to three milliamperes). As the current strength increased, the maxi-

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mum effect was more rapidly produced. When eight milliamperes were passed, the effect seemed immediate. Considerable heating of the parts in contact with the electrodes and of contiguous parts was noted on both make and break shocks. This continued to invade adjacent parts during the period of continued closure of the circuit, and the general effect included muscular fixation in most of the subjects experimented on.

In our previous Paper we concluded by deducing a danger ratio. This showed the danger of serious consequences on contact with the alternating current to be 41·5 times greater than that to continuous currents. So high a ratio was thought by many to be excessive, and the more recent experiments now set forth prove it to be so, *if we calculate it on exactly the same lines as before.* We find, however, that there are other factors which should be included in calculating the danger ratio in addition to those used in the former Paper, viz., "Differences in Resistance and Sensation." The difference in resistance obtained by the method we have now adopted and set forth in Tables A. and B. is 1·5, instead of 8·3 as obtained by the former method. The difference in sensation set forth in Tables D., E., and F., on the other hand, is 4·7, or only 0·3 less than that obtained previously. This would give a danger ratio of 7·0. Such a ratio, though far below that obtained with small battery and coil currents, would be sufficiently serious to demand very careful attention from electrical engineers, *if it represented the whole state of the case; but it does not* (as mentioned above) *cover the whole ground*, for we have also to consider two other factors, viz., Difference in Initial Shock and Difference in Continued Contact. On these two heads comparative values cannot be given. As regards initial shock, in which the time period of contact is a minimum, we have made many tests on various individuals, who one and all declare that the initial shock of alternating current of a certain strength is far worse to bear than the initial shock of continuous current of the same strength. This, from the nature of the experiments, can only be tested with small currents; and it is conceivable that with large currents such marked differences may not be observable, the time factor being left out of consideration. The second, however (continued contact), is a matter of far greater importance, as we have already pointed out in discussing muscular fixation. The time period of contact being appreciable with continuous current, we have no muscular fixation, and the subject of accidents would be able to release himself. On the other hand, an appreciable time of contact being made with an alternating-current circuit, the subject would be absolutely fixed *in situ* until released by extraneous aid, being exposed during the whole time to the full effect of the current passing through him. Further than this, the act of muscular contraction might and probably would increase the contact area, and so increase the current allowed to pass. When, therefore, we take these last-named factors into account it is manifest that the danger ratio of 41·5 to 1 named in our former Paper, is by no means too high. We do not now name another figure, because it appears to us impossible to express in terms that could be used for calculation the difference in initial shock and in continued contact.

It may perhaps be expected that we should make some reference to the quantity of current which constitutes a fatal dose, but this can only be arrived at by careful observation of all the electrical conditions prevailing at fatal accidents or executions. The difficulty of obtaining such information is unfortunately very great as regards accidents, but surely not as regards executions. That the authorities in charge of Kemmler's execution failed to take measurements of the E.M.F. and current strength used, is almost incredible, and in view of the fact that they possessed so excellent an opportunity such neglect seems quite inexcusable. For some time past we have been hoping that some information would be forthcoming; but the article by Mr. C. Huntly in the *Electrical World*, reproduced in the current number of the *Electrical Review*, seems conclusive; for it says, "No data of either the electrical or mechanical apparatus were taken." Mr. Perry, in his recent articles in American electrical journals, arrives at the conclusion that one ampere is an undoubtedly fatal current, provided it actually passes through the victim. This estimate we see no reason to differ from, though we hardly think sufficient evidence has been obtained on which to base really definite conclusions.

We will now briefly summarise our conclusions; and in doing so desire to draw attention to the fact that they are based upon certain conditions, and while we believe them to be sufficiently accurate and reliable under these conditions we in no sense claim them as true under all conditions.

Conclusions.

A. When the human body, with the skin in its normal unmoistened condition, comes into contact for an appreciable time with bare metal conductors of a dynamo-generated continuous current passing at about 100 volts in such a way that the current passes from hand to hand, and the total contact area is about 90 sq. centimetres:

(1.) A current of about 0·016 ampere will pass through it.

(2.) This current can be borne without discomfort for 15 to 30 seconds.

(3.) After about 30 seconds, unpleasant burning sensations become marked and quickly increase.

(4.) The subject is perfectly able to release himself at will during any portion of the time of contact.

B. When the human body comes into contact with dynamo-generated alternating currents, alternating at about 60 to 70 per second, under the same conditions as above:

(1.) A current of about 0·025 ampere will pass through it.

(2.) This current is six times greater than that which produces discomfort.

(3.) Instantly the subject is fixed by violent muscular contraction and suffers great pain.

(4.) The subject is utterly unable to release himself, but remains exposed to the full rigour of all the current that may be passing.

C. When circuit from electric light or power conductors is accidentally completed through the human body, the danger of serious consequences is many times greater when alternating than when continuous currents are passing at equal voltage, and this is still to a large extent true if the voltage of the continuous current be double that of the alternating.

D. (1.) With both forms of current a reduction of contact area materially reduces the amount of current strength that passes.

(2.) With the alternating current, if the rate of alternation be reduced below 50 per cent., the sensations of pain accompanying muscular fixation will be increased, while if the rate of alternation be increased the pain will be diminished.

Finally, we would remind those gentlemen who so commonly speak as if voltage were the chief or only factor in the danger of accidental contact, that *current strength is the important item*, and that according to Ohm's law current strength is dependent not only upon E.M.F. but upon the total resistance in circuit at the time of accidental contact. To make statements based upon voltage only, such as newspaper reports of a recent execution have contained, is not only distinctly misleading, but calculated to induce the uninitiated to form erroneous conclusions.

Thunderstorm Observations.—In a Paper recently communicated to the Hungarian Academy, M. Hegfroky gives the results of a study of five years' thunderstorms (1882-86) on the Hungarian plain. Days on which thunder was observed formed 16·4 per cent. of all days from April to September. Nearly half of the season's rainfall was on days of thunderstorm. Hail fell on 11 days, on one of which there was no thunderstorm. There were most thunderstorms in June (59 out of 199). The June of 1886 had as many as 26. The commencement of a thunderstorm occurred most often from 2 to 5 p.m. The author accepts Sohncke's theory that the electricity of thunderstorms is due to friction of water-drops on ice.

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The Electrician.

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TECHNICAL EDUCATION.

LORD DERBY, at Liverpool, and Mr. GLADSTONE, in different parts of the country, have been singing the praises of manual skill and of what has been called "the sacrament of physical work;" and in both cases their theme has been. "More technical schools, more technical education, and increased facility for the artisan class in obtaining a practical acquaintance with the more important truths of science and the accuracy and definiteness of scientific thought." Until quite recently we have never, as a nation, been conspicuous for the excellence of our State education, technical or otherwise; in fact, compared with other countries, we have been decidedly backward. As early as 1642, only ten years after the landing of the "Mayflower," the colonists of Massachusetts passed a law requiring every citizen, under a penalty of twenty shillings, to teach his children and apprentices, or have them taught, to read perfectly the English language; while not so very long afterwards a regulation was made that in every township of over 500 householders a school was to be opened to teach, among other subjects, book-keeping, surveying, geometry, natural philosophy, chemistry, and botany; a curriculum which, though not, strictly speaking, technical, at any rate embodies elements that could not fail to be of great service in everyday life. In France at the present day elementary instruction may be given at the State schools in agriculture, surveying, and levelling; while the excellence of the German technical schools needs no comment. In this respect, indeed, England will bear no comparison with her neighbours, and for the last few years the deficiency has been dwelt upon by politicians of every description save one. The strike agitators know better than to encourage skilfulness and intelligence. Since they are for the most part shrewd men, they are quite alive to the fact that a first-class skilled workman can nearly always command both a fair and a steady wage; and that as the main advantage which the trade unions offer over the many friendly and other insurance societies is a fund upon which he may sometimes be permitted to draw when he is out of work, they fail, as far as this is concerned, to attract thoroughly competent men. The dock labourers and other bodies who are ignorant enough to believe that there is an inherent antagonism between capital and labour are from lack of training devoid of the skill that will command six or

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seven shillings for a day's work at a vice, or prefer from indolence or want of ambition to continue in their unintelligent occupations. If the technical education that is being talked about will enable these classes to contribute to the never-failing market for skilled and intelligent labour to such an extent that their numbers will be diminished, and that the value of unskilled labour will rise, it will be the better for all; for we sympathise with no trade that cannot afford to pay a decent wage. This kind of education, however, is quite different from that which would enable the skilled artisan to acquire habits of systematic exactness of thought and of a grasp of scientific methods and processes.

These matters may be acquired while learning the elements of science which are taught at such admirable institutions as those of the City and Guilds of London and its many branches throughout the country, and at the numerous technical colleges of leading provincial towns.

We must remember, however, that the absence of State schools of this description is only an example of the policy of individual freedom hitherto adopted in all English internal administration, a policy which has come to the front most prominently under the phase of "Free Trade," and which always finds plenty of ability to support it. In no country save England is education almost entirely "run" by private individuals, nor is it usual for the great universities of a country to be as absolutely unconnected with the State as are our own. But in passing from the general question of State education to the particular branch in question, that of technical schools, it is instructive to observe the different results that its advocates anticipate from them. According to Lord DERBY their establishment is to inaugurate an era of breadth of mind and scientific accuracy of thought which will dissipate and neutralise the loose talk and inconclusive argument so painfully prevalent at the present day; while to Mr. GLADSTONE they are to be the panacea for the over-competition and low pay from which the present generation of clerks are suffering. Technical schools, he says, are to make things easier and brighter for the care-worn clerk who knows only English, and has to compete with the foreigner versed in two languages besides his own, and who works withal at a lower rate; but how they are to counterbalance the immigrants, who swarm over here in such numbers, Mr. GLADSTONE does not show. Nor are we struck by the honesty of his logic when he, in the first place, points out that the mechanic gets good pay because so many of his class rush off to be clerks, and thereby leave the field vacant to him, and then advises the clerks to throw down their pens and become mechanics because of the better remuneration offered. Mr. GLADSTONE occasionally seems to forget that if you give to one you take from another, and that no amount of such manipulation can add to or decrease the wage fund of a trade or of a country.

We have said enough to show that technical education is a subject the scope of which is not quite easy to grasp, owing to the loose manner in which the term has been used, especially when it is dragged in as a platform panacea for low wages and over-competition. Technical education of a certain sort there always has been and always must be; the young artisan now, as ever, learns his trade as a factory apprentice, according to many authorities the most profitable and most practical manner in which he could do so. Apprenticeship, indeed, is not what it was in the time of ELIZABETH, when seven years was the minimum term, and the apprentice was, in a manner, under the tutelage of his master; but still the workman when he has served his time has, to all intents and purposes, learnt his trade.

There is, however, a point at which serious fault may be found with the present system. As long as the trade or handicraft to be learnt is one of comparative simplicity, and consists merely in the development of manual skill, an empirical training is sufficient; but as soon as a higher level is reached it is imperative that the workman, if he is to produce really high-class work in his own department, should also have a fair knowledge of the collateral branches of the industry, and a tolerable acquaintance with the principles on which the creative skill of the factory is based, as well as a due appreciation of his share of the work. It is evident that to no industry do these remarks apply so forcibly as to that of electrical engineering. Yet how many of the workmen employed in making a dynamo, though highly skilled in their own department—that of manual labour—are acquainted with the most elementary principles of its design, or have even a hazy idea of the manner in which the current is generated? In work of this description there is true need for a general and suitable scientific education for the skilled workman, in addition to the manual dexterity he already possesses. We are scarcely so sanguine as Lord DERBY, who expects the artisan after this scientific course to have acquired either habits of accuracy in matters of fact, or a mastery of scientific methods. A truly great advance will have been achieved if he is able to form a more fitting estimate of the part he plays himself in the construction of the finished product, and if he takes a more generous and sympathetic view of the scientific labour of his masters.

REVIEWS.

Screw Threads, and Methods of Producing them, with numerous Tables and complete Directions for Screw Cutting Lathes. By PAUL N. HASLUCK. London: Crosby Lockwood. 1890.

This little pocket-book, which has now reached a third edition, contains a considerable amount of very useful information, and a number of well-arranged tables. It is not easy to decide on what should, and what should not, find a place in a pocket-book. The most common mistake is the use of matter which is really suitable for a text book.

A considerable portion of this pocket-book consists of information which is of the text book character, and is therefore out of place in a pocket-book. Elementary portions about the wrapping of a right-angled triangle round a cylinder; the difference between right and left-handed screws; descriptions of the commonest form of screwing tackle and of the screw cutting lathe are altogether unnecessary. It is doubtful if it is worth while to read about such matters even in a text book, since there is little to be said about them that cannot be more easily and surely learned in the workshop.

The description of standard threads and the tables containing the dimensions of the threads, of Whitworth nuts and bolts, and taps, are good; but they only occupy eight pages. For these tables and for sundry information in other sections, the book, which is only 3½in. by 2¼in. by ¼in., is worth having; but there are several matters which we might expect to find in a work, however small, on screw threads, which has run to a third edition. Among these are a table of change wheels for screw cutting, in place of part of the chapters which are devoted to the explanation of the principle and method of calculating the ratios, and a table and formulæ giving the strength of Whitworth bolts, &c. There is an amateur flavour in this little work which may account for the omission of the latter, for most amateurs seem to be interested in the mysteries of mandrel noses and of Holtzapffel's threads, and few ever think of calculating or even inquiring into the strength of a bolt. A page should be given to the design of nuts, and room could be found for a few wrinkles about impromptu taps, extracting broken screws, blacksmith's dodges for making vice screws, Archimedian drills, &c.

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ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 604.)

§ 13. **Westinghouse Transformers.**—The transformers or converters employed are illustrated in Fig. 34. The iron cores of the transformer consist of a pile of sheet-iron stampings, which are built up to encase the primary and secondary coils.

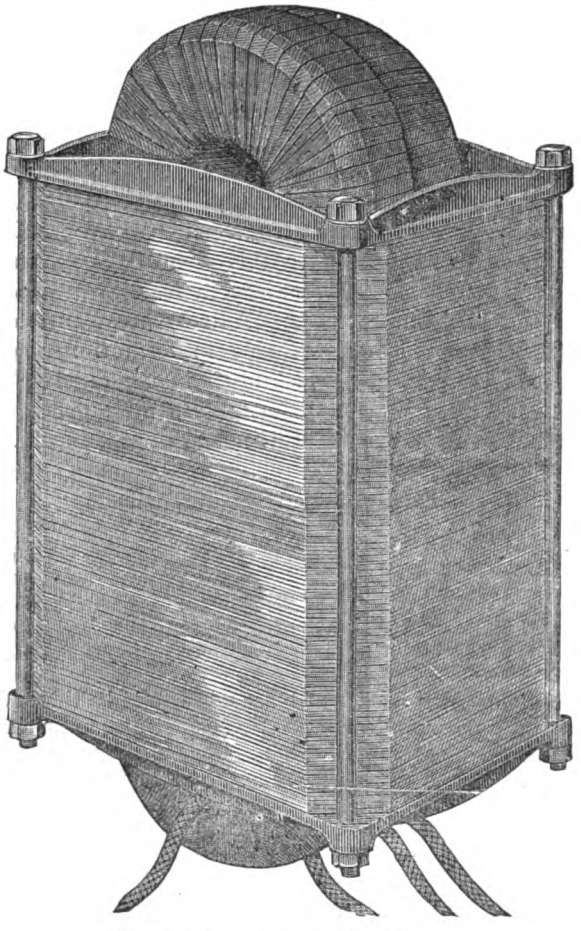

FIG. 34.—Westinghouse Transformer.

The sheet-iron stampings are shown in Fig. 35. The cross-piece, or tongue, is bent back when the rectangle is slipped over the coils, and re-bent back into place, so as to fill up the centre aperture of the coils. Each of these coils is composed of double covered wire, coated with an insulating compound,

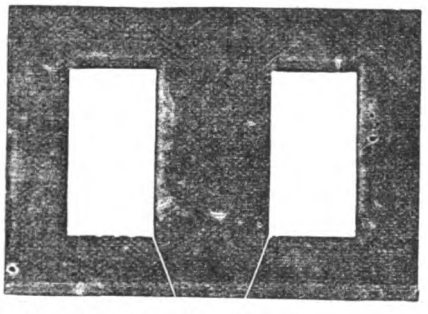

FIG. 35.—Sheet Iron Stamping of Westinghouse Transformer.

each layer of wire being insulated from its neighbour by additional insulation, and the completed coil covered with three separate and distinct coverings of insulating cloth. The contact between the primary and secondary coil is prevented by distance-pieces of insulating materials. The iron stampings are then piled up in and around the two coils (*see* Fig. 36), and the whole compressed by end-plates and tie-rods. The com-

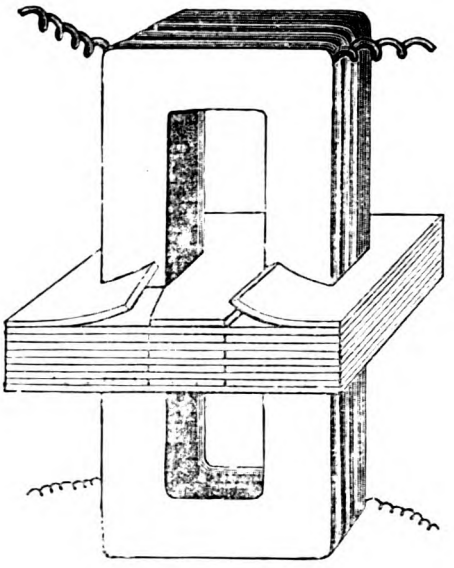

FIG. 36.

pleted converter is enclosed in a cast-iron box, the two halves of which are bolted together with a waterproof joint (*see* Figs. 37 and 38). The ends of the primary and secondary coils are brought out to face plates under swing lids. There are the

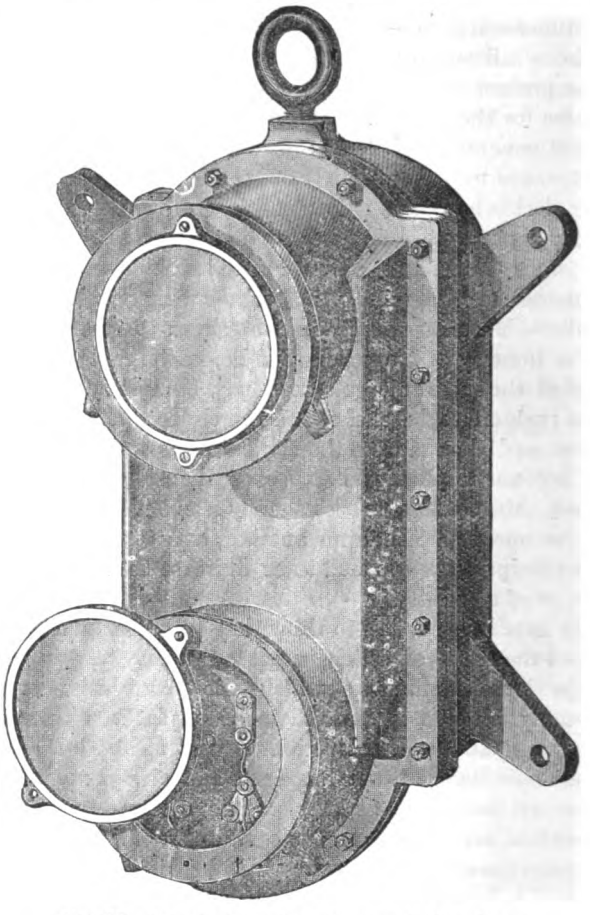

FIG. 37.—Westinghouse Transformer in Iron Case.

usual primary and secondary fuses, these being covered in with glass plates. The converter case has a ring and lugs by which it is attached to walls of buildings or to posts. A very usual practice is to affix the converter to the cross-arm of the

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post carrying the primary wires or to the walls of a building (*see* Figs. 39A and 39B).

The converters are manufactured in four sizes for 500, 1,000, 1,500, and 2,000 Watts output, or for 10, 20, 30, 40, 50-volt 16 candle-power lamps. It is generally the custom to employ

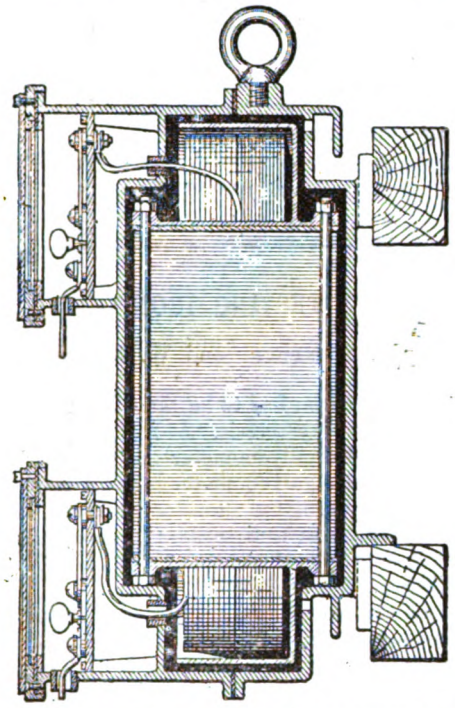

FIG. 38.—Section of Westinghouse Transformer in Case.

the converters singly on separate secondary circuits, and not to bank them with secondaries in parallel on the same circuit, as it is considered that if the primary fuse of one condenser "blows," the additional load thrown on the other converters is apt to break down the whole set. The transformer generally used lowers

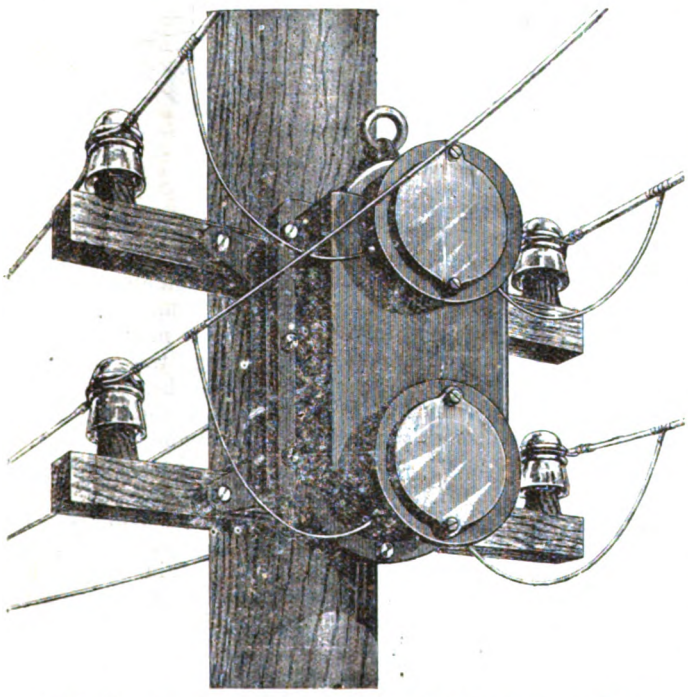

FIG. 39A.—Westinghouse Transformer affixed to cross-arm of post.

pressure from 1,000 volts to 50 volts. Although the converters are very light, and have a smaller quantity of iron in the cores than might be considered desirable, they appear to be efficient in performance. Comparative tests made by the calorimeter method at the Electrical Testing Bureau of the Johns Hopkins University, U.S.A., in 1889, gave results as follows for the electrical efficiencies of these transformers at various loads:—

Efficiency of Westinghouse Converters.

Capacity of transformer in 50-volt 16 candle-power lamps.	Power in watts supplied to primary circuit.	Output in watts on secondary circuit.	Watts lost.	Efficiency, in per cent.
	Full Load.			
10 lamps	585·3	504·0	81 3	85·9
20 ,,	1109·3	994·3	115·0	89·6
30 ,,	1529·0	1395·0	134·0	91·2
40 ,,	2151·0	2010·0	141·0	93 4
	Half Load.			
10 ,,	334 0	257·0	77·0	76 9
20 ,,	660 5	552·1	108·5	83·6
30 ,,	883 0	751·0	132 0	85 05
40 ,,	1243·4	1120·0	123 4	90·08

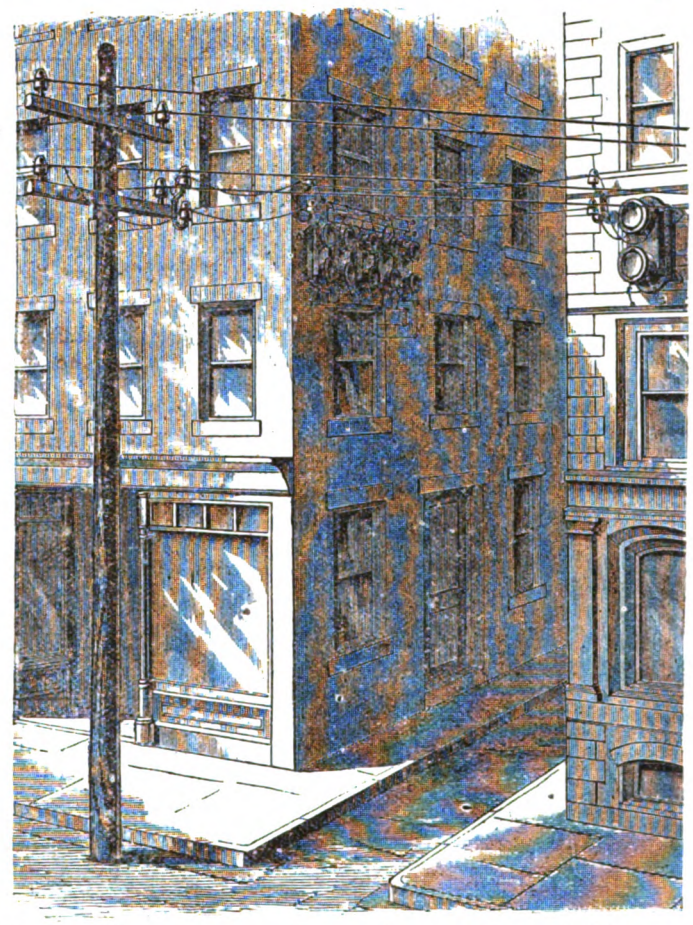

FIG. 39B.—Westinghouse Transformers affixed to exterior of buildings

Prof. G. Forbes, employing the same calorimeter method on a 30-light transformer, obtained an efficiency of 95 per cent. at half-load. The calorimeter method is, however, one somewhat difficult to carry out with accuracy, and such discrepancies in results are not unlikely to occur even between careful observers. Tests made by Mr. N. Marshall, under direction of Prof. Cross, at the Institute of Technology, Massachusetts, employing the calorimeter, and using a 20-light converter, gave an efficiency at full load of 93 per cent.* In this case the alternations were 14,530 per minute. Probably the most complete tests on the efficiency of these transformers are those of Dr. Louis Duncan and Mr. W. F. C. Hasson, made in 1890 at the testing laboratory of the Johns Hopkins University, on a 750-light Westinghouse plant.† The dynamo was driven through a Tatham dynamometer by an Armington and Sims engine. Engine,

* *Electrical World*, Vol. XV., January 18, 1890, p. 46.
† *Electrician*, Vol. XXIV., p. 593, 1890.

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dynamo, and dynamometer, were bolted down to heavy timbers, and the current conveyed to a bank of transformers of the 40-light size. These transformers supplied incandescent lamps. The efficiency of these converters was separately determined by a calorimeter method, by placing them in a metal box, with double walls, between which water was allowed to flow. The temperatures of the water at exit and entrance were observed, as well as the weight of water which passed through; at the same time the current and potential difference in the secondary circuit of the converter was measured. A series of corrections had to be applied for radiation. A 40-light and a 20-light converter were tested, with the results as under :—

Efficiency of a Westinghouse Converter, 40-Light.

No. of lamps on.	Volts of lamps.	Watts in secondary circuit.	Loss in watts in transformer.	Loss in iron in watts.	Efficiency, in per cent.
40	50·0	2,000	109	...	94·8
0	50·9	0	84	84	...

Efficiency of a Westinghouse Converter, 20-Light.

No. of lamps on.	Volts of lamps.	Watts in secondary circuit.	Loss in watts in transformer.	Loss in iron in watts.	Efficiency, in per cent.
20	48·8	952	106·0	95 2	90·0
15	52·2	817	114·8	108·9	87 6
10	50·3	506	101·7	99·2	83·3
5	51·44	264	109·4	108·7	70·7
0	52 3	0	110·5	110·5	0·

Experiments at slightly different primary potential differences showed that the loss in the iron varied very nearly as the square of the voltage.

The efficiency of the converters being determined, that of the dynamo alone could be found. A series of experiments was made, in which the power supplied to the pulley of the dynamo was compared with the electrical power taken up in the lamps on the secondary circuits of the transformers, and as a result the net or over-all efficiency of the system determined. The lamp load was taken at $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and full load, and the power determined.

Table of Efficiency of 750-Light Westinghouse Plant at Various Loads.

Load	Exciter.		Primary Circuit.		Secondary circuit.		Horse-power in lamp circuit.	Power supplied to dynamo.	Loss in transformation.	*Net* Efficiency, in per cent.
	E.M.F.	Current.	E.M.F.	Current.	E.M.F.	Current.				
¼	105	9·4	1107	10·0	49·5	153·9	10·21	21·83	11·62	46 8
½	104	10·5	1107	18·9	49·6	338·4	22·5	34·4	11·9	65·4
¾	101	11·0	1113	28·6	50·0	520·7	34·9	48·0	13 1	72 7
Full	112	11·5	1125	38·1	50·9	739·8	50·48	64·44	13 96	78·3

Looking at these figures, we see that there is even at no load only a small loss in the converters themselves, but there is a very considerable loss in the dynamo armature. The twenty 40-light converters supplying the 750 lights at full load absorb only some 2,000 watts, or about 3-horse power, when the secondary circuits are open; but since the total loss is at full load equal to 13-horse power, it follows that there is a loss of 10-horse power in the dynamo at full load. From the above figures it appears, however, that at full load the commercial efficiency of the alternating dynamo in itself reaches somewhere about 86 per cent. Taking a commercial load diagram for the 24 hours, and reckoning the average diurnal or "all day" efficiency of such a 750-light plant, we find it to be about 60 per cent. That is to say, that if such a plant were continuously supplying incandescent lamps in ordinary houses, 60 per cent. of the energy given to the dynamo in the 24 hours would be represented by electrical energy in the lamp circuits, and the rest would be dissipated in the machine and converters. In actual central-station work good arrangements and proper selection of the size of unit machine would keep the working dynamo plant very nearly fully loaded at the various hours of the day, and a considerably higher average efficiency might be attained in the all-day use of such properly divided plant. Further reference will be made to the question of the reduction of the diurnal waste as far as regards the transformers and the relative advantages of transformer centres and large and small transformers.

(To be continued.)

TESTING IRON.*

By J. Swinburne and W. F. Bourne.

In practical work iron has to be tested as to its permeability and as to the loss by hysteresis. As regards permeability tests, the ordinary ballistic galvanometer method can, of course, be used; but a ballistic galvanometer is not a convenient instrument, and the method is too slow for practical use. It may, therefore, be of interest to describe the apparatus we use commercially. It is the development of a method devised in 1886. (See *Phil. Mag.*, July, 1887.)

The various samples of iron are obtained in the form of wire, and made up into rings, being wound on a former kept for the purpose, so that all the rings are alike as to dimensions. Before winding, the specific gravity of the iron is taken by weighing, and the specific resistance is measured. The ring is weighed to get the volume of iron, and is then wound with suitable primary and secondary wires.

The arrangement is shown diagrammatically in the annexed figure :—

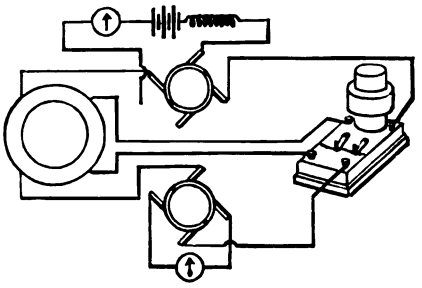

Diagram of Arrangements.

The circuit from secondary cells is led through an adjustable resistance, then through an ammeter to a commutator, resembling Brillouin's, which is driven by a belt from any shafting that may be near. The circuit is led through the primary to an induction box to the ring under test, and then back to the commutator. The circuit is then led back to the cells. The induction box consists of a primary coil, standing on end, and a number of secondary coils arranged so that the mutual induction is the same for all of them. The secondary coils are led to buttons, and the switches include them by ones or tens, making the readings in steps of one per cent. of the highest. The primary of the sample ring is in series with that of the induction box. The secondaries are coupled so as to oppose each other, and arranged in circuit with a second commutator; a Varley, or, as it is more often called, a Deprez d'Arsonval galvanometer, being inserted in the circuit. The two commutators are, of course, on the same spindle. The adjustment of the induction box was carried out as follows: The coils were roughly calculated to give a mutual induction a little in excess of a convenient round number per turn of secondary. A cylinder of a known diameter with a known number of turns per centimetre in the primary, and a known number of turns in the pilot coil was taken, and

*Paper read before the British Association in Section A, Leeds, September 1890.

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put in the place of the sample ring, and its mutual induction measured with the induction box. To allow for the error due to the shortness of the cylinder of the standard coil, it was slipped out of the pilot coil, and moved exactly half its length in a direction along its axis, and a new reading taken. This reading gave the error due to the ends of the cylinder. A shunt was then put across the primary induction box, so as to make the readings come out in microhenrys.

To test a sample of iron all that is necessary is to alter the mutual induction by steps, and to bring the galvanometer to zero for each step by means of the adjustable resistance. As the galvanometer is dead-beat, the readings can be taken in a few minutes.

The importance of loss by hysteresis in alternate-current work is only now beginning to be fully realised. There are several ways of measuring the loss in transformers, but none of them seem satisfactory. Sometimes the transformer is put in a calorimeter, or else it is assumed that the pressure and even the exciting current vary harmonically, and have a so-called "angle of lag." The published efficiencies of most transformers are got by finding the loss from the copper resistances, and neglecting the loss in iron altogether. There is still another method, and that is taking the curves of pressure and current. Prof. Ryan has been singularly successful in this with a modification of Joubert's method.

Tests of transformers by means of lag angles and calorimeters have been published by Profs. Ferraris and Ayrton, and Major Cardew. As the loss in a transformer can be divided into the loss in the copper which varies as the square of the load, and the loss in the iron by hysteresis and Foucault currents which remains constant, these results can be checked. The results published, as obtained by these experimenters, show inaccuracies that make them quite valueless. The loss in the iron in Prof. Ayrton's experiments varies 160 per cent. of its smallest value, while Prof. Ferraris' cores give out power working as refrigerators. (See article "On Induction and other Things," *Electrical Review*, October, 1887.)

There is really little reason for measuring the loss in a transformer; it is much simpler to measure the loss in the iron. No one would think of measuring the loss in the copper by means of a calorimeter or angle of lag method. All that is needed is to measure the effective current and multiply its square by the resistance, the resistance being determined from the specific resistance of copper, or by direct measurement. Similarly, in the case of the iron, it is best to determine the qualities of the iron once for all, and then the efficiencies of all transformers made of it can be foretold.

We use the same rings as for the permeability test, but do not employ the secondary wires. The loss of power at various frequencies and inductions is taken with a wattmeter. It is sometimes supposed that a wattmeter cannot be made with little enough self-induction to read accurately. If there is much self-induction in the pressure or shunt circuit, the reading will be lower than that with a direct current if there is no self-induction in the circuit in which the waste of power is to be measured; but if the current is behind the pressure, as in measuring the loss in iron, the wattmeter may even read too high. We therefore designed a special instrument, which was made for us by pupils of the London College of Electrical Engineers. The current coils are fixed, and the moving coil is suspended by a fine wire, with a fine spring at the foot, to take the electricity out again. The moving coil has few turns and little self-induction, and a large non-ductively wound resistance is in series with it. This wattmeter can be read with a mirror, if desired; but with 2,900 ohms in series with the pressure coil, it gives a torsion of 2° per watt on a non-inductive resistance. The series resistance is not wound with a looped wire as is usual in resistance boxes, because this method is not good, the insulation being apt to break down. A single wire was therefore used. When one layer was wound, the bobbin was reversed in the lathe, and the next layer wound in the opposite direction, a thin layer of insulation being put between the layers. This method secures absence of self-induction, and good insulation, as the beginning and end of the coil are kept well apart. The readings are taken by bringing the index back to zero by turning the suspension, so that the mutual induction of the coils is zero, as the coils are at right angles.

The self-induction of the pressure coil was not directly measured, as that would give us no useful information, as we do not know the variation of the current and pressure of air dynamos. They certainly do not vary harmonically, and at full load the pressure rises slowly and falls suddenly in each half period.

The wattmeter was therefore subjected to a severe test. Readings were first taken with direct currents on a resistance; readings were then taken on the same resistance with an alternate current. This resistance had very little self-induction, so that any self-induction in the pressure coil should lessen the reading, by making the current in the pressure coil lag, and also by reducing it. The reading with the alternate current was 2·1 per cent. less than with the direct. This figure is entered in the note-books, but though it is too small to matter in our work, it is larger than it ought to be. The next test was to measure the power taken by a coil with the same current and same pressure, but with no resistance and large self-induction. It is difficult to make up a coil with no iron core to take 50 volts and 10 amperes with no appreciable loss by resistance; we therefore took a hedgehog transformer, and measured the power taken by it. The reading was taken with 50 volts and 4·2 amperes. If the pressure coil had any appreciable self-induction, the reading would be considerable; it might, in fact, be anything up to about 200 watts. The least self-induction would increase the reading enormously. The reading was 11 watts, and the calculated loss by copper and iron in the transformer with only 50 volts on its secondary was 10·3; so the wattmeter is practically correct. Let it be supposed, however, that the loss in iron was really less than this, and that the loss was two watts less than the reading. This is an extreme assumption; but we may see how much such an error would affect our readings of the sample rings. The assumed error is 1 per cent. of the product of the pressure and current. Now, in the case of a closed iron circuit the power is about half the product; so this would lead to an error of 2 per cent. in the loss in the iron. In a closed-circuit transformer the loss in iron is, roughly speaking, 10 per cent. at full load, and about 40 per cent., to take a low figure, taken over the day; so that the error would be 0·2 per cent. and 1 per cent. In the hedgehog form the loss in iron is about 1·5 per cent. at full, and 15 per cent. at all day loads; so the errors are ·03 and 0·3 per cent. respectively, which are too small to matter. As a matter of fact, they are much less than the various errors of observation that creep into such work. Measuring the power in an open-circuit transformer is also a most difficult case, for the least self-induction then gives rise to the largest error; in measuring the power in a closed circuit ring the errors are less.

We give a number of curves of permeability and of $\int E\,dQ$ per cubic centimetre for different samples of iron. These are practically the same as curves of $\int I\,dH$; but $\int E\,dQ$ seems a better way of writing it, as $\int I\,dH$ can scarcely be said to have any physical meaning, and has even had the effect of not suggesting that the reversal involves waste of energy; indeed, it seems to have rather disguised the fact.

In completing these curves some corrections have been made. The wattmeter absorbs some power itself, as the pressure coil circuit is led through the current coils. We might have compensated for this in one of the ways described to Section A by one of us in 1887, but in this case did not think it worth while. The Foucault current losses are also corrected. The losses in the wires themselves can be calculated with rigid accuracy, as explained in a Paper on "Transformer Design," which one of us had the honour of reading before Section G last year. There might also be some loss by Foucault currents, due to imperfect insulation between the wires of the core. The insulation is, however, too good to allow this; in fact, the resistance between two wires, about an inch apart, runs into ohms, the measurement being seven ohms in the particular example taken. The losses by Foucault currents are frequently over-estimated by writers on the subject. If the specific resistance of the iron is known, they can nearly always be calculated with much greater

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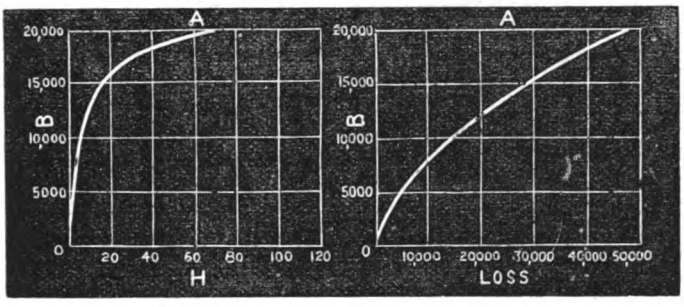
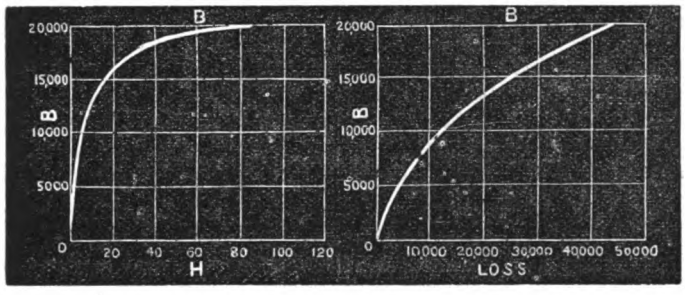
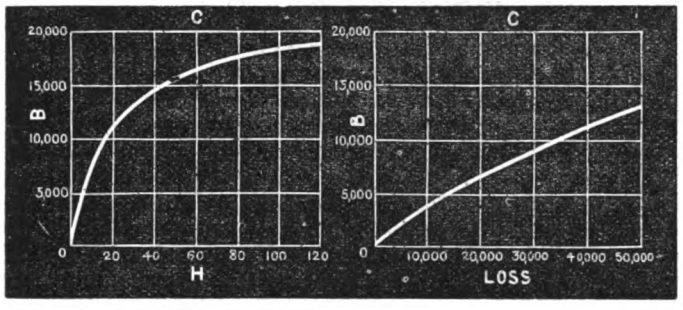
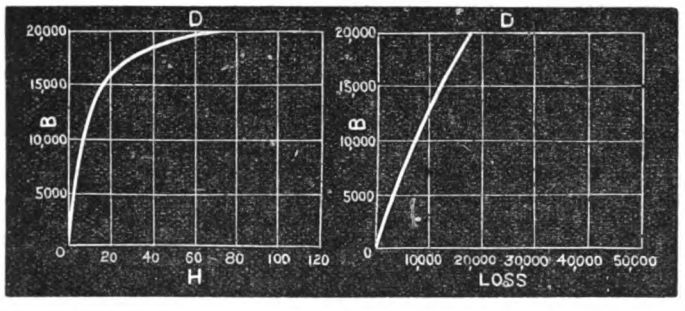
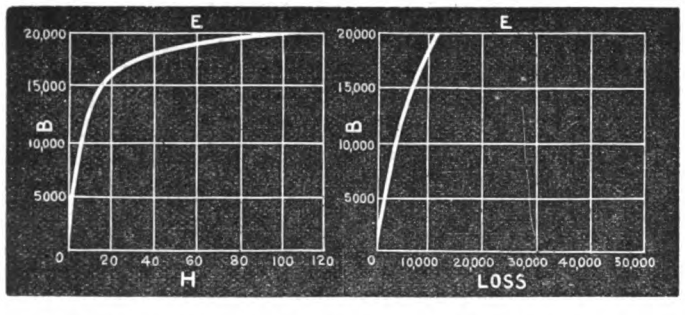
accuracy than they can be measured. The loss by the copper resistance is also allowed for in the curves. Though it is generally the practice to give all the steps in a Paper like this, we think it better to give the results only; for, though the Paper then looks less imposing than if full of curves and calculations, it is more likely to be useful.











We have not yet tested the same sample at very different frequencies to see if there is any time lag. From the comparatively small loss at high frequencies it is not probable there is any appreciable time lag.

BRITISH ASSOCIATION.

DISCUSSION ON ELECTRICAL STANDARDS.

The following is a report of the discussion which arose at the recent meeting of the British Association at Leeds on the reading of the Report of the Committee on Electrical Standards (see *The Electrician*, September 26, p. 587), and the four Appendices thereto (see *The Electrician*, October 3, p. 608, p. 613, p. 615, p. 616, and p. 637 of present issue).

Prof. G. F. FITZGERALD, referring to the specimens of copper which gave a very abnormal density, and had an abnormally low conductivity, asked whether they had been annealed, or whether annealing would alter them, and also where the copper came from.

Mr. H. A. TAYLOR said that he supplied one of the specimens referred to—No. VII. of the Table. The conductivity was increased 2·2 per cent. by thorough annealing; and the peculiar feature of the hard-drawn copper was that it had never been heated.

Mr. JAMES SWINBURNE asked whether the Association was thinking of doing anything with regard to Joule's equivalent. In some American books, Wood's "Thermo-Dynamics," for instance, the figure of 784 was given as the most recent determination. If there was any chance of there being an error in that, surely it was a very important thing that it should be determined again.

Dr. J. A. FLEMING said the question of the secular changes in resistance coils was rather important. He was inclined to think that it would perhaps be better to use some form of liquid paraffin, rather than to use paraffin wax, as was generally done. The members of the committee, he was sure, thoroughly appreciated the great value of the work Mr. Glazebrook was doing in keeping a very careful watch upon these coils. These seven or eight coils constituted the prime standards of electrical resistance for all the world, and they were practically like the standard pound or the standard yard preserved at the Board of Trade. It was most important that most careful watch should be kept upon them, in order to detect any secular changes in the alloys. It was an unfortunate fact that nearly all those substances which were the most suitable for the construction of standards of resistance were more or less complicated alloys. The simple metals which would probably be better fitted for permanent standards had very large temperature coefficients. Some experiments had recently been made in the United States on two rather interesting alloys, one of which had actually a negative co-efficient of change of resistance for temperature. They were alloys consisting of copper, nickel, and ferro-manganese; and the interesting part about them was this—that one of these alloys, in one particular condition of annealing, was just like carbon and the electrolytes: it had a negative co-efficient. It had been found that by a suitable combination of these two alloys it was possible to have an alloy which did not change its resistance at all for variation of temperature. It was not at all impossible that we might one day arrive at a suitable alloy of this kind, which perhaps would be of sufficient permanence. But, unfortunately, these ferro-manganese alloys were not at all likely to be used, from the fact that they were found to change their resistance somewhat, even under the small currents that are used for measuring them. His acquaintance with the Cambridge coils had ceased for some time; but he seemed to recollect that the gold-silver coil at one time gave them some anxiety as to a change of standard temperature, but if he followed Mr. Glazebrook it was the platinum-silver coil now that gave them anxiety. As Mr. Glazebrook said, it was rather a serious matter that a coil of platinum-silver having a small temperature coefficient should have changed so much. All these things seemed to point to the fact that a more complete and very careful investigation of the change of resistance of alloys with time required to be made. With regard to the method of testing the capacity of the condensers by the revolving commutator, he made a great many experiments on that method about two years ago, with fairly satisfactory results. The method was to drive a commutator by a small electro-motor. The commutator had an arrangement by which he could alter the duration of the contacts. He wanted to see what was the influence of the duration of the contacts on the capacity—to see how long the contact must be made in order to avoid cutting off the tails of the discharges. He found that when the duration of the contact was about eight or ten times that of the time-constant of the condenser circuit the discharge was complete. He made a number of very careful comparisons between condensers in his own possession and some standard condensers—micro-farads—which showed that this method could be employed with very considerable accuracy. It could also be employed very well for the measurement of the capacity of small condensers like Leyden jars by using a differential galvanometer. By putting a current through a resistance in series with one coil of a differential galvanometer and then a current from the condenser through the other coil, he was able to make very easily determinations as to the capacities of Leyden jars of different sizes. The method seemed to afford considerable facility for dealing with these small capacities, and he had no doubt that for comparisons between the condensers to be employed as standards, it would be about as good a method as any that could be adopted.

Sir W. THOMSON said he was very glad that Dr. Fleming had called attention to the alloys having negative temperature coefficients. It would be interesting to electricians to know that the subject was under examination in Helmholtz's new research laboratory. He had been informed (though he was not quite certain of this) that arrangements were being made for giving out wire in which there would be no temperature variation. At all events, as the matter was being investigated by very able

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hands in Berlin, as well as in America, they might soon hope to see coils in which they would not be troubled with any temperature error for measuring electrical resistances, that they would be able to have an instrument with a slight negative temperature coefficient to absolutely compensate the effect of the positive temperature coefficient.

Mr. A. P. TROTTER said that as the committee were dealing with the question of the resistance of copper, it might be important to determine exactly what they meant by "copper." Then, again, annealing and tempering were said to introduce a very large change; and the phrase, "thorough annealing" was used. Surely, if annealing did produce any change, they ought to know what was meant by "thorough annealing." Another variety of copper is known in America, though not in this country, as "tempered copper." It was perfectly well known that ordinary commercial copper contained a considerable quantity of oxygen; and a question arose as to whether electro-deposited copper was entirely free from occluded gas. The question was not purely a chemical one, and it was important that it should be determined, if copper was to be used.

Sir W. THOMSON said it was important to know the time occupied in "thorough tempering." Thorough tempering might extend over days or weeks, and might produce very different results according to the duration of the process.

Prof. G. F. FITZGERALD said there seemed to be a difference in the effect on alloys and on pure metals.

Sir W. THOMSON: It is just possible that the pure metals may be worse. I do not know of any alloy which is so liable to great differences, in consequence of very small impurities, as is pure copper.

Mr. R. T. GLAZEBROOK said the way in which the annealing was done was to enclose the wire in a copper case, to pack it tightly with asbestos, and lampblack, and shut it up, then to heat it thus for some hours with a Bunsen burner, and then leave it to cool slowly by gradually turning down the flame for something like from 24 to 36 hours. In several cases there had been more than one annealing.

Sir W. THOMSON suggested, with reference to the use of lampblack, that the presence of carbon might have a very great effect. He well remembered some experiments made about 25 years ago on the elastic fatigue of wires. It was found that copper wires heated very hot in powdered charcoal, kept hot for a considerable time and, then allowed to cool very slowly, became very brittle. The subject was not pursued, but it seemed that there was an effect from the powdered charcoal. The lampblack, with the asbestos, might have the same effect; and it might, therefore, be desirable to try annealing with asbestos alone, with charcoal powder, and then with asbestos and lampblack, as in the present case.

Prof. G. F. FITZGERALD said that if the copper was at all impure on account of the mixture of oxide, the superficial layer would form carbon monoxide, and that would probably diffuse in the inside and would reduce the oxide of copper that was in the inside.

Prof. OLIVER J. LODGE pointed out that it must not be assumed for certain that there was anything the matter with the platinum-silver alloy, which was only one ingredient in the changed coils; he further asked whether Mr. Glazebrook, in speaking about coil F having changed much, meant more than one in ten thousand or thereabouts; and lastly, what sort of squared paper had been used for the diagrams.

Prof. JOHN PERRY said that, when experimenting on spiral springs, on taking out two or three lengths of platinum-silver wire very near one another, which were, as far as he could judge, flattened and twisted in the same way, he had found that perhaps one out of every three was utterly different in its behaviour from the others, and was no longer elastic. Two pieces would be perfectly elastic, but the third seemed to be of quite a different material.

Lord RAYLEIGH said that in connection with the errors in copper containing minute traces of impurity, it was worth mentioning an experience he had last summer. He was passing pure hydrogen over copper. The copper wire was of the kind ordinarily used for electrical apparatus of high conductivity. He found that the hydrogen, after passing over, contained sulphuretted hydrogen; it seemed impossible to get any copper which did not give off sulphur, and give it off apparently for an almost indefinite time. Some of the wires were heated for hours nearly every day for weeks, but they yielded sulphuretted hydrogen at the end. When they were taken out they were found to be absolutely brittle; suggesting the idea, at any rate, that the removal of the sulphur, and possibly of oxygen, had been fatal to their mechanical properties.

Mr. SEARLE, in describing the commutator employed in the Cavendish Laboratory, said there was a tuning-fork acting in the well-known manner, with two slits on the prongs, and through those slits there was viewed a stroboscope disc on a wheel attached to the commutator. It was driven by a water motor by a fine fishing-line joined with a splice —a knot was no good at all; every time a knot went over the man at the galvanometer called out. They did not govern the commutator by the bands driving the commutator, but by a small secondary band going from the water-motor to a pulley within easy reach of the observer. In that way they got rid, not only of the inertia of the commutator itself, but also of that of the fly-wheel of the water-motor, which was very considerable; and they were by that means able to keep the speed pretty constant. The stroboscopic disc enabled them to get considerable variations of speed bearing definite relations one to another. As to what Dr. Fleming was saying about the probability of measuring extremely small capacities by means of this commutator, Prof. Thomson was able to measure the capacities of ordinary small copper wire. The capacities of the connecting wires of the various condensers had been, of course, carefully allowed for.

Mr. R. T. GLAZEBROOK, replying to the discussion, said, in regard to the annealing and the preparing of the copper, he was afraid that in his endeavour to be brief he had not been quite just to the very great care which Mr. Fitzpatrick had taken with regard to a large number of these points. There was an almost unanimous feeling among copper manufacturers that small quantities of oxide are necessary to give tenacity to the copper, and that there is a certain amount of oxide in all the copper wire. The reason why it was annealed in charcoal was to get rid of that oxide; and he thought that in almost all cases the wire did come out brittle, as Sir William Thomson had described, but at the same time it came out with a very much reduced resistance. In the preparation of the copper by Mr. Fitzpatrick himself he should have stated that the hydrogen was passed over the copper for hours while in a finely-divided state at a considerable temperature. Mr. Fitzpatrick had now a specimen of copper which he had prepared entirely by chemical means, not by electrolytic deposition at all. He had hoped to have been able to give the results of the observations to the Section; but, unfortunately, a tube suitable for reducing the copper could not be obtained in England, and the last of a stock which Mr. Fitzpatrick had obtained from Germany broke three days before he (Mr. Glazebrook) came away. Mr. Fitzpatrick had another stock on order (indeed, it had been on order for months), but the tubes had not arrived; and so the copper was there awaiting its final chemical reduction and purification. He fancied that the copper did become distinctly brittle and lose its tenacity when one got rid of the last traces of oxide, and possibly also of sulphur, as Lord Rayleigh had mentioned. The table gave in most cases the results of annealing. Regarding the temperature coefficients, he knew Matthiessen's formula, and it was given in the paper. The number he had put upon the blackboard was only intended to be approximate. He thought that number was obtained by observations ranging from 16°C to nearly 100°C; and where he had criticised it was in extending that formula down from 16°C to 0°C. He had not been able to find any observations of Matthiessen's at a lower temperature than 16°C. If Mr. Taylor had numbers lower than 16°, and near 0°C, they would be of extreme value to the report. Dr. Fleming referred to the point he had raised about the effects of mechanical strain. It might be within the recollection of the Section that in the last clauses of the Report he asked for further resistance coils. It was his intention to wind those coils entirely free from paraffin. He had not yet made up his mind as to the exact form, and he should be very glad to talk the matter over, and have Dr. Fleming's very valuable assistance. As to alloys with negative temperature coefficients, he hoped to have some specimens of the wire before very long, and possibly next year to make a communication to the Section upon it. As regards the platinum-silver alloy, his own impression was that the effect alluded to was not a change in the alloy, but a mechanical change produced in the alloy by the effects of the strain. He hoped that any electricians who were present and who had old coils of the Association would kindly lend them to him again, as was done a couple of years ago, in order that he might compare them, and see whether there was any evidence of change in them. The amount of change for the coil F was a rise of ·00063; the fall for G was ·0002; the fall for H was ·0001 B.A. units. Prof. Perry's remarks about the platinum-silver alloy entirely bore out some observations of his own as to the very different nature of coils of platinum-silver wire, taken from the same bobbin, which showed quite a different constitution. He did not mean, however, that there was a large difference in the temperature coefficient. The squared paper was ordinary wall-paper; and Mr. Griffiths, when he sent it, hoped that it would not remind the Section too much of the bath-rooms. In reference to the value of Joule's equivalent, he entirely agreed with Mr. Swinburne that it was worthy of very careful consideration. Probably the best results were those of Prof. Rowland, and, no doubt, those were what Mr. Swinburne quoted.

THE HEDGEHOG TRANSFORMER.

At the British Association meeting of last year, Mr. Swinburne contended that an open iron circuit could be made more efficient than any form of closed iron-circuit transformer. In calculating the efficiencies of transformers, the loss in the iron has generally been left completely out of account, and the loss in copper alone considered. If the loss by hysteresis is taken into account the loss in iron in closed-circuit transformers, as usually designed, is some 10 per cent. of the full load. As the loss in iron goes on all the time a transformer is in circuit this is very serious. The proportion of actual to possible output of energy per day varies in different districts, but in most stations the average use of lamps is less than two hours a day, including all the lamps installed. The transformer must be large enough to feed all the lamps installed, so it runs, say, an average of two hours of full load a day. If there is a loss of 10 per cent. of full load in the iron, this gives an actual efficiency of 45·5 per cent., even neglecting the loss in copper. In the hedgehog form (see Figure) the proportion of iron is very much reduced. The result is, that even in small transformers the iron loss is under 1 per cent. of the full load. One per cent. of the full load gives 89 per cent. all day, neglecting copper loss, against the 45 per cent. of the closed circuit. This is neglecting copper, however, and the copper loss is greater in the hedgehog form, so this is an exaggerated comparison. Such a transformer really has an efficiency of about 87 per cent. all day.

If a closed iron circuit is used, the iron circuit must be long to embrace the copper coils. The only way to shorten it is to make the copper coils smaller. This means using a higher current density, which is wasteful, or fewer turns of copper. Fewer turns

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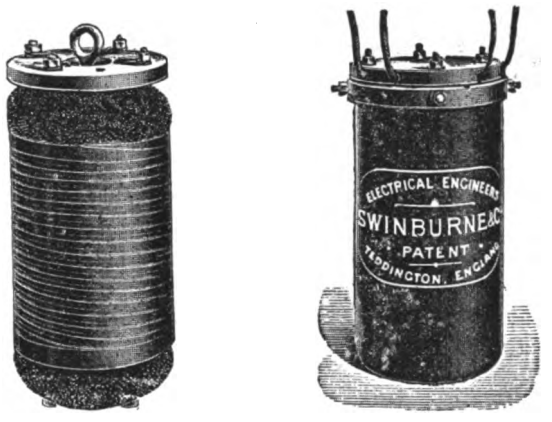
of copper demand either a higher induction in the iron, or a greater cross-section, and both of these mean greater loss by hysteresis. If the iron circuit is opened, the sides of the embracing core can be removed, so the loss by hysteresis is divided by three. As there is now plenty of room for copper, the turns and cross-section can be increased, and the iron reduced still further. The object of introducing the closed-iron circuit was to reduce the magnetic resistance. An open-circuit transformer has much higher magnetic resistance. The question of magnetic resistance is not so important as might at first sight appear. Its increase demands more excitation or more magneto-motive force, and this increases the loss in copper. The best form is thus a compromise. The hedgehog ends are to reduce the magnetic resistance. In a conductive circuit the resistance is low if the current density is low in all parts where the specific resistance is high. Similarly, in a composite magnetic circuit of iron and air, the magnetic resistance is low if there is never a high magnetic current density or induction in the air, which has high specific magnetic resistance. The magnetising current in a hedgehog is high, but as it is a quarter of a period behind the primary current in phase, and as the primary wire has to be large enough to carry the primary current, the loss in watts is small. As this loss goes on all day, however, it is by no means unimportant, and has to be included in getting out the efficiencies of these transformers.

The construction of these transformers, as carried out by Messrs. Swinburne and Co., of Teddington, is very simple. A gun-metal casting of cross-shaped section forms the backbone. It is spread out at each end, forming legs at one and taking the circular terminal board at the other. It also carries insulating flanges, which form the ends of the coils. Into the four recesses in the core are put four bundles of soft iron wire. These are taped over, and the secondary is wound on. The secondary is



Swinburne's Hedgehog Transformer.

then covered with two layers of ebonite, and the flanges are also faced with the same material. The primary is then wound on in two compartments, separated with ebonite, after the manner invented by Gramme so that both ends come outside, and as far removed from each other as possible. The ends of the core are then spread out, and the transformer tested under 4,000 or 5,000 volts; the insulation in megohms being read by an instrument which measures the effective resistance under an alternating current. As iron cases cannot be used, as they would be magnetised by the transformer, and as any metal would have Foucault currents generated in it, stoneware jars, specially made for the purpose, are used for cases. These have lids bolted down with holes for the leads.

Mr. Nikola Tesla criticises Mr. Swinburne's arguments in the *Electrical Engineer* of New York. The hysteresis loss occurring in closed-circuit transformers at full load is asserted to be, instead of 10 per cent., no more than 6 per cent., provided the iron is good, and the converter is intelligently used. The proportion of actual to possible daily output of energy is said to be larger than Mr. Swinburne asserts, when due care is taken in distributing the load, and when, as in many cases, entire circuits are shut off when not required. The open-circuit form of converter is subject to many disadvantages when operated at the usual period; and in comparing the hysteresis loss with that occurring in the closed-circuit type, the fact that the loss depends, within certain limits, upon the square of the magneto-motive force, may easily be overlooked. The diminution of the amount of iron, it is true, lessens the hysteresis, but the increased magneto-motive force needed to produce the same output partially counteracts the effect. Four Swinburne transformers joined so as to form a closed magnetic circuit would probably be more efficient than one alone. The magnetic resistance would be less, and the exciting current could be diminished. The electric heating depends on the square of the current flowing, and this amount of waste heat may be by no means insignificant.

Mr. Tesla asserts that the tendency to shorten the magnetic circuit in transformers is due principally to practical considerations, the extra efficiency gained by reducing the magnetic resistance being of minor importance. Whether the open-circuit transformer is an improvement or not will depend principally on the period. The experience of most engineers has resulted in the adoption of the closed-circuit form; and Mr. Tesla, who claims to have been the first to advocate the open-circuit type of converter, states that to improve the efficiency he found it necessary to use a higher period, and that at usual periods the closed-circuit form was preferable.

If an anchor ring of iron is wound *all over* with primary and secondary wires, the best result is got at a particular period. If another ring of the same material and cross section, but of double the circumference, is similarly wound, the maximum effect occurs at the *same period*, and the efficiency is the same. Thus a transformer of any capacity can be made, provided the primary and secondary coils completely cover the core. If only a fraction of the ring is covered by the wires, the smaller transformer is more efficient, and it thus becomes important to shorten the magnetic circuit. Practical considerations have prompted the best makers to enclose the wires as much as possible with laminated iron.

THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON.

(Continued from page 624.)

General Principles of Design and Construction.—Principle of the Magnetic Circuit.

To-night we have to discuss the law of the magnetic circuit in its application to the electro-magnet, and in particular to dwell upon some experimental results which have been obtained from time to time by different authorities as to the relation between the construction of the various parts of an electro-magnet, and the effect of that construction on its performance. We have to deal not only with the size, section, length, and material of the iron cores, and of the armatures of iron, but we have to consider also the winding of the copper coil, and its form; and we have to speak in particular about the way in which the shaping of the core and of the armature affects the performance of the electro-magnet in acting on its armature, whether in contact or at a distance. But before we enter on the last more difficult part of the subject, we will deal solely and exclusively with the law of force of the magnet upon its armature when the two are in contact with one another; in other words, with the law of traction.

I alluded in a historical manner in my first lecture to the principle of the magnetic circuit, telling you how the idea had gradually grown up, perforce, from a consideration of the facts. The law of the magnetic circuit was, however, first thrown into shape in 1873 by Prof. Rowland, of Baltimore. He pointed out that if you consider any simple case, and find (as electricians do for the electric circuit) an expression for the magnetising force which tends to drive the magnetism round the circuit, and divide that by the resistance to magnetisation reckoned also all round the circuit, the quotient of those two gives you the total amount of flow or flux of magnetism. That is to say, one may calculate the quantity of magnetism that passes in that way round the magnetic circuit in exactly the same way as one calculates the strength of the electric current by the law of Ohm. Rowland, indeed, went a great deal further than this, for he applied this very calculation to the experiments made by Joule more than 30 years before, and from those experiments deduced the degree of magnetisation to which Joule had driven the iron of his magnets, and by inference obtained the amount of current that he had been causing to circulate. Now this law requires to be written out in a form that can be used for future calculation. To put it in words without any symbols, we must first reckon out from the number of turns of wire in the coil, and the number of amperes of current which circulates in them, the whole *magneto-motive force*—the whole of that which tends to drive magnetism along the piece of iron—for it is, in fact, proportional to the strength of the current, and the number of times it circulates. Next we must ascertain the resistance which the magnetic circuit offers to the passage of the magnetic lines. I here avowedly use Joule's own expression, which was afterwards adopted by Rowland, and, for short, so as to avoid having four words, we may simply call it the *magnetic resistance*. Mr. Heaviside has suggested as an advisable alternative term, magnetic *reluctance*, in order that we may not confuse the resistance to magnetism

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

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in the magnetic circuit with the resistance to the flow of current in an electric circuit. However, we need not quarrel about terms; magnetic reluctance is sufficiently expressive. Then having found these two, the quotient of them gives us a number representing—I must not call it the strength of the magnetic current—I will call it simply the quantity or number of magnetic lines which flow round the circuit; or, if we could adopt a term which is used on the Continent, we might call it simply *the magnetic flux*; the flux of magnetism being the analogue of the flow of electricity in the electric law. The law of the magnetic circuit may then be stated as follows:—

$$\text{Magnetic flux} = \frac{\text{magneto-motive force}}{\text{reluctance}}.$$

However, it is more convenient to deal with these matters in symbols, and therefore the symbols which I use, and have long been using, ought to be explained to you. For the number of spirals in a winding I use the letter S; for the strength of current, or number of amperes, the letter i; for the length of a bar, or core, I am going to use the letter l; for the area of cross-section, the letter A; for the permeability of the iron which we discussed in the last lecture, the Greek symbol μ; and for the total magnetic flux, the number of magnetic lines, I use the letter N. Then our law becomes as follows:—

$$\text{Magneto-motive force } \frac{4\pi S i}{10};$$

$$\text{Magnetic reluctance.. } \Sigma \frac{l}{A\mu};$$

$$\text{Magnetic flux ..... } N = \frac{\frac{4\pi \cdot S i}{10}}{\Sigma \frac{l}{A\mu}}.$$

If we take the number of spirals and multiply by the number of amperes of current, so as to get the whole amount of circulation of electric current expressed in so many ampere-turns, and multiply it by 4π, and divide by 10, in order to get the proper unit (that is to say, multiply it by 1·257), that gives us the magneto-motive force. For magnetic reluctance, calculate out the reluctance exactly as you would the resistance of an electric conductor to the flow of electricity, or the resistance of a conductor of heat to the flow of heat; it will be proportionate to the length, inversely proportional to the cross-section, and inversely proportional to the conductivity, or, in the present case, to the magnetic permeability. Now, if the circuit is a simple one, we may simply write down here the length, and divide it by the area of the cross-section and the permeability, and so find the value of the reluctance. But if the circuit be not a simple one, if you have not a simple ring of iron of equal section all round, it is necessary to consider the circuit in pieces as you would an electric circuit, ascertaining separately the reluctance of the separate parts, and adding all together. As there may be a number of such terms to be added together, I have prefixed the expression for the magnetic reluctance by the sign Σ of summation. But it does not by any means follow because we can write a thing down as simply as that, that the calculation out of it will be a very simple matter. In the case of magnetic lines we are quite unable to do as one does with electric currents to insulate the flow. An electric current can be confined (provided we do not put it in at 10,000 volts pressure, or anything much bigger than that) to a copper conductor by an adequate layer of adequately strong—and I use the word "strong" both in a mechanical and electrical sense—of adequately strong insulating material. There are materials whose conductivity for electricity as compared with copper may be regarded perhaps as millions of millions of millions of times less; that is to say, they are practically perfect insulators. There are no such things for magnetism. The most highly insulating substance we know of for magnetism is certainly not 10,000 times less permeable to magnetism than the most highly magnetisable substance we know of, namely, iron in its best condition; and when one deals with electro-magnets where curved portions of iron are surrounded with copper, or with air, or other insulating material, one is dealing with substances whose permeability, instead of being infinitely small, compared with that of iron, is quite considerable. We have to deal mainly with iron when it has been well magnetised. Its permeability compared with air is from 1,000 to 100 roughly; that is to say, the permeability of air compared with the iron is not less than from one one-hundredth to one one-thousandth part. That means that it is quite possible to have a very considerable leakage of magnetic lines from iron into air occurring to complicate one's calculations, and prevent an accurate estimate being made of the true magnetic reluctance of any part of the circuit. Suppose, however, that we have got over all these difficulties, and made our calculations of the magnetic reluctance; then dividing the magneto-motive force by the reluctance gives us the whole number of magnetic lines.

There, then, is in its elementary form the law of the magnetic circuit stated exactly as Ohm's law is stated for electric circuits. But as a general rule one requires this magnetic law for certain applications, in which the problem is not to calculate from those two quantities what the total of magnetic lines will be. In most of the cases a rule is wanted for the purpose of calculating back. You want to know how to build a magnet so as to give you the requisite number of magnetic lines. You start by assuming that you need to have so many magnetic lines, and you require to know what magnetic reluctance there will be, and how much magneto-motive force will be needed. Well, that is a matter precisely analogous to those which every electrician comes across. He does not always want to use Ohm's law, in the way in which it is commonly stated, to calculate the current from the electromotive force and the resistance; he often wants to calculate what is the electromotive force which will send a given current through a known resistance. And so do we. Our main consideration to-night will be devoted to the question how many ampere-turns of current circulation must be provided in order to drive the required quantity of magnetism through any given magnetic reluctance. Therefore, we will state our law a little differently. What we want to calculate out is the number of ampere-turns required. When once we have got that, it is easy to say what the copper wire must consist of; what sort of wire, and how much of it. Turning, then, to our algebraic rule, we must transform it, so as to get all the other things besides the ampere-turns, to the other side of the equation. So we write the formula:—

$$Si = \frac{N \cdot \Sigma \frac{l}{A\mu}}{1{\cdot}257}$$

We shall have then the ampere turns equal to the number of magnetic lines we are going to force round the circuit multiplied by the sum of the magnetic reluctances divided by 1 257. Now this number, 1·257, is the constant that comes in when the length, l, is expressed in centimetres, the area in square centimetres, and the permeability in the usual numbers. Many persons unfortunately—I say so advisedly because of the waste of brain labour that they have been compelled to go through—prefer to work in inches and pounds and feet. They have, in fact, had to learn tables instead of acquiring them naturally without any learning. If the lengths be specified in inches, and areas in square inches, then the constant is a little different. The constant in that case, for inches and square inch measures, is 0·3132, so that the formula becomes:—

$$Si = N \times \Sigma \frac{l''}{A''\mu} \times 0{\cdot}3132.$$

Here it is convenient to leave the law of the magnetic circuit, and come back to it from time to time as we require. What I want to point out before I go to any of the applications is, that with the guidance provided by this law, one after another the various points that come under review can be arranged and explained, and that there does not now remain—if one applies this law with judgment—a single fact about electro-magnets which is either anomalous or paradoxical. Paradoxical some things may seem in form, but they all reduce to what is perfectly rational when one has a guiding principle of this kind to tell you how much magnetisation you will get under given circumstances, or to tell you how much magnetising power you require in order to get a given quantity of magnetisation. I am using the word "magnetisation" there in the popular sense, not in the narrow mathematical sense in which it has sometimes been used (*i.e.*, for the magnetic moment per unit cube of the material). I am using it simply to express the fact that the iron or air, or whatever it may be, has been subjected to the process which results in their being magnetic lines of force induced through it.

Now let us apply this law of magnetic circuit in the first place to the traction—that is to say, the lifting power of electro-magnets. The law of traction I assumed in my last lecture, for I made it the basis of a method of measuring the amount of permeability. The law of magnetic traction was stated once for all by Maxwell, in his great treatise, and it is as follows:—

$$P\,(\text{dynes}) = \frac{B^2 A}{8\pi},$$

where A is the area in square centimetres. This becomes

$$P\,(\text{grammes}) = \frac{^2A}{8\pi \times 981}.$$

That is, the pull in grammes per square centimetre is equal to the square of the magnetic induction, B (being the number of magnetic lines to the square centimetre), divided by 8π, and divided also by 981. To bring grammes into pounds you divide by 453·6; so that the formula then becomes:—

$$P\,(\text{lbs.}) = \frac{B^2 A}{11{,}183{,}000};$$

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or if square inch measures are used :—

$$P\ (\text{lbs.}) = \frac{B^2{}_{''}\,A''}{72{,}134{,}000}.$$

To save future trouble we will now calculate out from the law of traction the following Table ; in which the traction in grammes per square centimetre or in pounds per square inch is set down opposite the corresponding value of B.

Table VI.—*Magnetisation and Magnetic Traction.*

B lines per sq. cm.	$B_{''}$ lines per sq. inch.	Dynes per square centimetre.	Grammes per square centimetre.	Kilogrs. per sq. centim.	Pounds per sq. inch.
1,000	6,450	39,790	40·56	·0456	·577
2,000	12,900	159,200	162·3	·1623	2·308
3,000	19,350	358,100	365·1	·3651	5·190
4,000	25,800	636,600	648·9	·6489	9·228
5,000	32,250	994,700	1,014·0	1·014	14·39
6,000	38,700	1,432,000	1,460·0	1·460	20·75
7,000	45,150	1,950,000	1,987·0	1·987	28·26
8,000	51,600	2,547,000	2,596·0	2·596	36·95
9,000	58,050	3,223,000	3,286·0	3·286	46·72
10,000	64,500	3,979,000	4,056·0	4·056	57·68
11,000	70,950	4,815,000	4,907·0	4·907	69·77
12,000	77,400	5,730,000	5,841·0	5·841	83·07
13,000	83,850	6,725,000	6,855·0	6·855	97·47
14,000	90,300	7,800,000	7,550·0	7·550	113·1
15,000	96,750	8,953,000	9,124·0	9·124	129·7
16,000	103,200	10,170,000	10,390·0	10·39	147·7
17,000	109,650	11,500,000	11,720·0	11·72	166·6
18,000	116,100	12,890,000	13,140·0	13·14	186·8
19,000	122,550	14,360,000	14,630·0	14·63	208·1
20,000	129,000	15,920,000	16,230·0	16·23	230·8

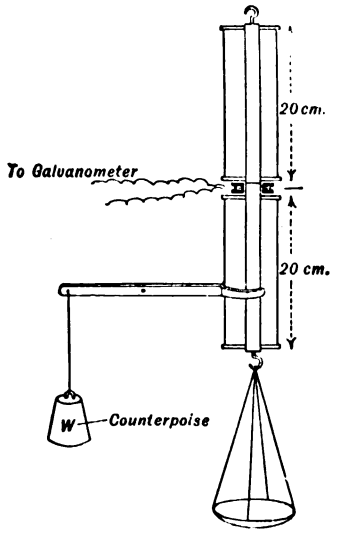

Fig. 22.—Bosanquet's Verification of the Law of Traction

This simple statement of the law of traction assumes that the distribution of the magnetic lines is uniform all over the area we are considering ; and that, unfortunately, is not always the case. When the distribution is not uniform, then the mean value of the squares becomes greater than the square of the mean value, and consequently the pull of the magnet at its end face may, under certain circumstances, become greater than the calculation would lead you to expect—greater than the average of B would lead you to suppose. If the distribution is not uniform over the area of contact, then the accurate expression for the tractive force (in dynes) will be—

$$P = \frac{1}{8\pi}\int B^2 dA,$$

the integration being taken over the whole area of contact.

This law of traction has been verified by experiment. The most conclusive investigations were made about 1886 by Mr. R. H. M. Bosanquet, of Oxford, whose apparatus is depicted in Fig. 22. He took two cores of iron, well faced, and surrounded them both by magnetising coils, fastened the upper one rigidly, and suspended the other one on a lever with a counterpoise weight. To the lower end of this core he hung a scale-pan, and measured the traction of one upon the other when a known current was circulating a known number of times round the coil. At the same time he placed an exploring coil round the joint, that exploring coil being connected, in the manner with which we were experimenting last week, with a ballistic galvanometer ; so that at the moment when the two surfaces parted company, or at the moment when the magnetisation was released by stopping the magnetising current, the galvanometer indication enabled him to say exactly how many magnetic lines went through that exploring coil. So that, knowing the area, you could calculate the number per square centimetre, and you could therefore compare B^2 with the pull per square centimetre obtained directly on the scale-pan. Bosanquet found that even when the surfaces were not absolutely perfectly faced the correspondence was very close indeed, not varying by more than 1 or 2 per cent. except with small magnetising forces, say forces less than five C.G.S. units. When one knows how irregular the behaviour of iron is when the magnetising forces are so small as this, one is not astonished to find a lack of proportionality. The correspondence was, however, sufficiently exact to say that the experiments verified the law of traction, that the pull is proportional to the square of the magnetic induction through the area, and integrated over that area.

Now the law of traction being in that way established, one at once begins to get some light upon the subject of the design of electro-magnets. Indeed, without going into any mathematics, Joule had foreseen this when he in some instinctive sort of way seemed to consider that the proper way to regard an electro-magnet for the purpose of traction was to think how many square inches of contact surface it had. He found that he could magnetise iron up until it pulled with a force of 175lb. to the square inch, and he doubted whether a traction as great as 200lb. per square inch could be obtained.

In the following Table Joule's results (*see* Table I.) are re-calculated, and the values of B deduced :—

Table VII.—*Joule's Results Re-calculated.*

Description of electro-magnet.	Section. sq. in.	Section. sq. cm.	Load. lbs.	Load. kilos.	lbs. per sq. in.	kilos. per sq. cm.	B	Ratio of load to weight.
Joule's own electro-magnets No. 1..	10	64·5	2090	947	104·5	7·35	13,600	139
Joule's own electro-magnets No. 2..	0·196	1·26	49	22	125	8·75	14,700	824
Joule's own electro-magnets No. 3..	0·0436	6·28	12	5·4	137·5	9·75	15,410	1,286
Joule's own electro-magnets No. 4..	0·0012	0·0077	0·202	0·09	81	5·7	11,830	2,384
Nesbit's	4·5	29·1	142·8	647	158·5	11·2	16,550	28
Henry's	3·94	25·3	750	340	95	6·7	12,820	36
Sturgeon's	0·196	1·26	53	22·6	127·5	8·96	14,850	114

I will now return to the data on Table VI., and will ask you to compare the last column with the first. Here are the various values of B, that is say, the amounts of magnetisation you get into the iron. You cannot conveniently crowd more than 20,000 magnetic lines to the square centimetre of the best iron, and, as a reference to the curves of magnetisation shows, it is not expedient in the practical design of electro-magnets to attempt, except in extraordinary cases, to crowd more than about 16,000 magnetic lines into the square centimetre. The simple reason is this : that if you are working up the magnetic force, say from 0 up to 50, a magnetising force of 50 applied to good wrought iron will give you only 16,000 lines to the square centimetre, and the permeability by that time has fallen to about 320. If you try to force the magnetisation any further, you find that you have to pay for it so greatly. If you want to force another 1,000 lines through the square centimetre, to go from 16,000 to 17,000, you have to add on an enormous magnetising force ; you have to double the whole force from that point to get another 1,000 lines added. Obviously, it would be much better to take a larger piece of iron, and not to magnetise it too highly—to take a piece a quarter as large again, and to magnetise that less forcibly. It does not, therefore, pay to go much above 16,000 lines to a square centimetre—that is to say, expressing it in terms of the law of traction, and the pounds per square inch, it does not pay to design your electro-magnet so that it shall have to carry more than about 150lb. to the square inch. This shall be our practical rule : let us at once take an example If you want to design an electro-magnet to carry a load of one ton, divide the ton, or 2,240lb., by 150, and that gives the requisite number of square inches of wrought iron, namely, 14·92, or, say, 15. Of course, one would work with a horseshoe-shaped magnet, or something equivalent—something with a return circuit—and calculate out the requisite cross-section, so that the total area exposed might be sufficient to carry the given load at 150lb. to the square inch. And, as a horse-shoe magnet has two poles, the cross-section of the bar of which it is made must be 7½ square inches. If of round iron, it must be about 3½in. in diameter ; if of square iron, it must be 2¾in. each way.

That settles the size of the iron, but not the length. Now, the length of the iron, if one only considers the law of the magnetic circuit, ought to be as short as it can possibly be made. Reflect for what purpose we are designing. The design of an electro-magnet is to be considered, as every design ought to be, with a view to the ultimate purpose to be served by that which you are designing. The present purpose is the actual sticking on of the

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magnet to a heavy weight, not acting on another magnet at a distance, not pulling at an armature separated from it by a thick layer of air; we are dealing with traction in contact. The question is—how long a piece of iron shall we need to bend over? The answer is—take length enough, and no more than enough, to permit of room for winding on the necessary quantity of wire to carry the current which will give the requisite magnetising power. But this latter we do not yet know; it has to be calculated out by the law of the magnetic circuit—that is to say, we must calculate the magnetic flux, and the magnetic reluctance as best we can; then from these calculate the ampere-turns of current; and from this calculate the needful quantity of copper wire, so arriving finally at the proper length of the iron core. It is obvious the cross-section being given, and the value of B being prescribed, that settles the whole number of magnetic lines, N, that will go through the section. It is self-evident that length adds to the magnetic reluctance, and, therefore, the longer the length is, the greater have to be the number of ampere-turns of circulation of the current; while the less the length is, the smaller need be the number of ampere-turns of circulation. Therefore you should design the electro-magnet as stumpy as possible—that is to say, make it a stumpy arch, even as Joule did when he came across the same problem, and arrived, by a sort of scientific instinct, at the right solution. You should have no greater length of iron than is necessary in order to get the windings on. Then you see we cannot absolutely calculate the length of the iron until we have an idea about the winding, and we must settle, therefore, provisionally, about the windings. Take a simple ideal case. Suppose we had an indefinitely long, straight iron rod, and we wound that from end to end with a magnetising coil. How thick a coil, how many ampere-turns of circulation per inch length, will you require in order to magnetise up to any particular degree? It is a matter of very simple calculation. You can calculate exactly what the magnetic reluctance of an inch length of the core will be. For example, if you are going to magnetise up to 16,000 lines per square centimetre, the permeability will be 320. You can take the area anything you like, and consider the length of one inch; you can therefore calculate the magnetic reluctance per inch of conductor, and then you can at once say how many ampere-turns per inch would be necessary in order to give the desired indication of 16,000 magnetic lines to the square centimetre. And knowing the properties of copper wire, and how it heats up when there is a current; and knowing also how much heat you can get rid of per square inch of surface, it is a very simple matter to calculate what minimum thickness of copper the fire insurance companies would allow you to use. They would not allow you to have too thin a copper wire, because if you provide an insufficient thickness of copper, you still must drive your amperes through it to get a sufficient number of ampere turns per inch of length; and if you drive those amperes through copper winding of an insufficient thickness the copper wire will over-heat, and your insurance policy will be revoked. You therefore are compelled, by the practical consideration of not over-heating, to provide a certain thickness of copper wire winding. I have made a rough calculation for certain cases, and I find that for such electro-magnets as one may ordinarily deal with, it is not necessary in any case of practical work to use a copper wire winding, the total thickness of which is greater than about half an inch; and, as a matter of fact, if you use as much thickness as half an inch, you need not then wind the coil all along, for if you will use copper wire winding, no matter what the size, whether thin or thick, so that the total thickness of copper outside the iron is half an inch, you can, without over-heating, using good wrought iron, make one inch of winding do for 20in. length of iron—that is to say, you do not really want more than $\frac{1}{40}$th of an inch of thickness of copper outside the iron to magnetise up to the prescribed degree of saturation that indefinitely long piece of which we are thinking, without overheating the outside surface in such a way as to violate the insurance rules. Take it roughly, if you wind to a thickness of half an inch, the inch length of copper will magnetise 20in. length of iron up to the point where B equals 16,000. If then we have a bar bent into a sort of horse-shoe in order to make it stick on to a perfectly-fitting armature also of equal section and quality, we really do not want more than one inch along the inner curve for every 20in. of iron. An extremely stumpy magnet, such as I have sketched in Fig. 23, will therefore do, if one can only get the iron sufficiently homogeneous throughout. If, instead of crowding the wire near the polar parts, we could wind entirely all round the curved part, though the layer of copper winding would be half an inch thick inside the arch, it would be much less outside. Such a magnet, provided the armature fitted with perfect accuracy to the polar surfaces, and provided a battery were arranged to send the requisite number of amperes of current through the coils, would pull with a force of one ton, the iron being but 3$\frac{1}{2}$ins. in diameter. For my own part, in this case I should prefer not to use round iron, one of square or rectangular section being more convenient; but the round iron would take less copper in winding, as each turn would be of minimum length if the sections were circular.

Now, this sort of calculation requires to be greatly modified directly one begins to deal with any other case. A stumpy, short magnetic circuit with great cross-section is clearly the right thing for the greatest traction. You will get the given magnetisation and traction with the least amount of magnetising force when you have the area as great as possible, and the length as small as possible. You will kindly note that I have given you as yet no proofs for the practical rules that I have been using; they must come later. Also I have said nothing about the size of the wire, whether thick or thin. That does not in the least matter; for the ampere-turns of magnetising power can be made up in any desired way. Suppose we want on any magnet 100 ampere-turns of magnetising power, and we choose to employ a thin wire that will only carry half an ampere, then we must wind 200 turns of that thin wire. Or, suppose we choose to wind it with a thick wire that will carry 10 amperes, then we shall want only 10 turns of that wire. The same weight of copper, heated up by the corresponding current to an equal degree of temperature, will have equal magnetising power when wound on the same core. But the rules about winding the copper will be considered later.

Now, if you look in the text-books that have been written on magnetism for information about the so-called lifting power or portative force of magnets—in other words, their traction—you will find that from the time of Bernoulli downwards, the law of portative force has claimed the attention of experimenters, who, one after another have tried to give the law of portative force in terms of the weight of the magnets, usually dealing with permanent magnets, not electro-magnets. Bernoulli gave* a rule, something of the following kind, which is commonly known as Häcker's rule—

$$P = a\sqrt[3]{W};$$

where W is the weight of the magnet, P the greatest load it will sustain, and a a constant depending on the units of weight chosen,

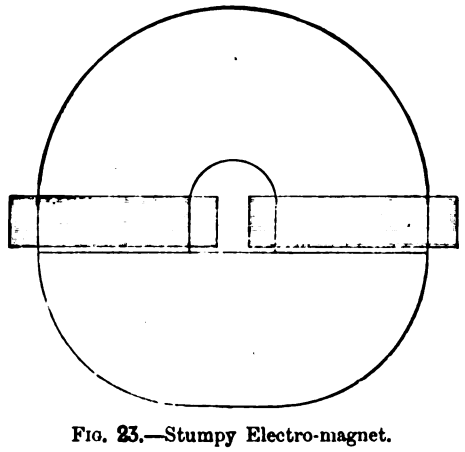

Fig. 23.—Stumpy Electro-magnet.

on the quality of the steel, and on its goodness of magnetisation. If the weights are in pounds then a is found, for the best steels, to vary from 18 to 24 in magnets of horse-shoe shape. This expression is equivalent to saying that the power which a magnet can exert—he was dealing with steel magnets; there were no electro-magnets in Bernoulli's time—is equal to some constant multiplied by the three-halfth root of the weight of the magnet itself. The rule is accurate only if you are dealing with a number of magnets all of the same geometrical form, all horse-shoes let us say, of the same general shape, made from the same sort of steel similarly magnetised. In former years I pondered much on Häcker's rule, wondering how on earth the three-halfth root of the weight could have anything to do with the magnetic pull; and having cudgelled my brains for a considerable time, I saw that there was really a very simple meaning in it. What I arrived at† was this. If you are dealing with a given material, say hard steel, the weight is proportional to the volume, and the cube root of the volume is something proportional to the length, and the square of the cube root forms something proportional to the square of the length—that is to say, to something of the nature of a surface. What surface? Of course, the polar surface. This complex rule, when thus analysed, turns out to be merely a mathematician's expression of the fact that the pull for a given material magnetised in a given way is proportional to the area of the polar surface; a law which in its simple form Joule seems to have arrived at naturally, and which in this extraordinarily academic form was arrived at by comparing the weights of magnets with the weight which they would lift. You will find it stated in many books that a good magnet will lift 20 times its own weight. There never was a more fallacious

* "Acta Helvetica," Vol. III., p. 233, 1758.

† *Philosophical Magazine*, July, 1888.

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rule written. It is perfectly true that a good steel horse-shoe magnet weighing 1lb. ought to be able to pull with a pull of 20lb. on a properly-shaped armature. But it does not follow that a magnet which weighs 2lb. will be able to pull with a force of 40lb. It ought not to, because a magnet that weighs 2lb. has not poles twice as big if it is the same shape. In order to have poles twice as big you must remember that three-halfth root coming in. If you take a magnet that weighs eight times as much, it will have twice the linear dimensions and four times the surface ; and with four times the surface in a magnet of the same form, similarly magnetized, you will have four times the pull. With a magnet eight times as heavy you will have only four times the pull. The pull, when other things are equal, goes by surface, and not by weight, and therefore it is ridiculous to give a rule saying how many times its own weight a magnet will pull. It is also narrated as a very extraordinary thing that Sir Isaac Newton had a magnet, a loadstone, which he wore in a signet ring, which would lift 234 times its own weight. I have had an electro-magnet which would lift 2,500 times its own weight, but then it was a very small one, and did not weigh more than a grain and a-half. When you come to small things, of course the surface is large proportionally to the weight ; the smaller you go, the larger becomes that disproportion. This all shows that the old law of traction in that form was practically valueless, and did not guide you to anything at all, whereas the law of traction, as stated by Maxwell, and explained further by the law of the magnetic circuit, proves a most useful rule.

From this digression let us return to the law of the magnetic circuit. I gave you in my first lecture, when speaking of permeability, the following rule for calculating the magnetic induction B :—Take the pull in pounds, and the area of cross section in square inches, divide one by the other, and take the square root of the quotient ; then multiplying by 1,317 gives B ; or multiplied by 8,494 gives $B_{\prime\prime}$. We have therefore a means of stepping from the pull per square inch to $B_{\prime\prime}$, or from $B_{\prime\prime}$ to the pull per square inch. Now the other rule of the magnetic circuit also enables us to get from the ampere turns down to $B_{\prime\prime}$, for on p. 891, we have the following expression for the ampere-turns :—

$$S\,i = N \times \Sigma \frac{l''}{A''\mu} \times 0{\cdot}3132,$$

and N, the whole number of magnetic lines in the magnetic circuit is equal to $B_{\prime\prime}$ multiplied by A″, or

$$N = B_{\prime\prime} A''.$$

From these we can deduce a simple direct expression, provided we assume the quality of iron as before, and also assume that there is no magnetic leakage, and that the area of cross-section is the same all round the circuit, in the armature as well as in the magnet core. So that l'' is simply the mean total path of the magnetic lines all round the closed magnetic circuit. We may then write

$$S\,i = \frac{B_{\prime\prime}\, l''}{\mu} \times 0{\cdot}3132 ;$$

whence—

$$B_{\prime\prime} = \frac{\mu \times S\,i}{l'' \times 0{\cdot}3132}.$$

But by the law of traction, as stated above,

$$B_{\prime\prime} = 8494 \sqrt{\frac{P\ (\text{lbs.})}{A\ (\text{sq. in.})}}.$$

Equating together these two values of $B_{\prime\prime}$, and solving, we get for the requisite number of ampere-turns of circulation of exciting currents :—

$$S\,i = 2661 \times \frac{l''}{\mu} \times \sqrt{\frac{P\ (\text{lbs.})}{A\ (\text{sq. in.})}}$$

This, put into words, amounts to the following rule for calculating the amount of exciting power that is required for an electro-magnet pulling at its armature, in the case where there is a closed magnetic circuit with no leakage of magnetic lines. Take the square root of the pounds-per-square-inch ; multiply this by the mean total length (in inches) all round the iron circuit ; divide by the permeability (which must be calculated from the pounds-per-square-inch by help of Table VI. and Table II.) ; and finally multiply by 2,661 : the number so obtained will be the number of ampere-turns. One goes then at once from the pull per square inch to the number of ampere-turns required to produce that pull in a magnet of given length, and of the prescribed quality. In the case where the pull is specified in kilogrammes, the area of section in square centimetres, and the length in centimetres, the formula becomes

$$S\,i = 3951. \frac{l}{\mu} \sqrt{\frac{P}{A}}.$$

As an example, take a magnet core of round annealed wrought iron, half an inch in diameter, 8in. long, bent to horse-shoe shape. As an armature, another piece, 4in. long, bent to meet the former. Let us agree to magnetise the iron up to the pitch of pulling with 112lb. to the square inch. Reference to Table VI. shows that $B_{\prime\prime}$ will be about 90,000, and Table II. shows that in that case μ will be about 907. From these data calculate what load the magnet will carry, and how many ampere-turns of circulation of current will be needed.

Ans.—Load (on two poles) =43·97lbs.
Ampere-turns needed =372·5

N.B.—In this calculation it is assumed that the contact surface between armature and magnet is perfect. It never is ; the joint offers additional resistance to the magnetic lines, and there will be some leakage. It will be shown later how to estimate these effects, and to allow for them in the calculations.

Here let me go to a matter which has been one of the paradoxes of the past. In spite of Joule, and of the laws of traction, showing that the pull is proportional to the area, you have this anomaly—that if you take a bar-magnet having flat ended poles, and measure the pull which its pole can exert on a perfectly flat armature, and then deliberately spoil the truth of the contact surface, rounding it off, so making the surface gently convex, the convex pole, which only touches at a portion of its area instead of over the whole, will be found to exert a bigger pull than the perfectly flat one. It has been shown by various experimenters, particularly by Nicklès, that if you want to increase the pull of a magnet with armatures, you may reduce the polar surface. Old steel magnets were frequently purposely made with a rounded contact surface. There are plenty of examples. Suppose you take a straight round core, or one leg of a horseshoe, which answers equally, and take a flat-ended rod of iron of same diameter as an armature ; stick it on endwise, and measure the pull when a given amount of ampere-turns of current is circulating round. Then,

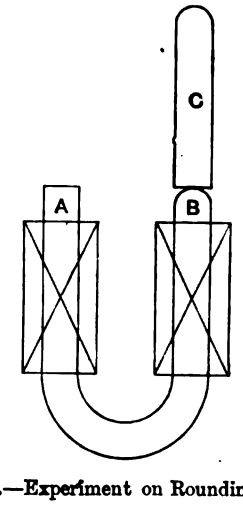

Fig. 24.—Experiment on Rounding Ends.

having measured the pull, remove it and file it a little, so as to reduce it at the edges ; or take a slightly narrower piece of iron, so that it will actually be exerting its power over a smaller area, you will get a greater pull. What is the explanation of this extraordinary fact ? A fact it is, and I will show it to you. Here, Fig. 24, is a small electro-magnet, which we can place with its poles upwards. This was very carefully made, the iron poles very nicely faced, and on coming to try them it was found they were nearly equal, but one pole, A, was a little stronger than the other. We have, therefore, rounded the other pole, B, a little ; and here I will take a piece of iron, C, which has itself been slightly rounded at one end, though it is flat at the other. I now turn on the current to the electro-magnet, and I take a spring-balance, so that we can measure the pull at either of the two poles. When I put the flat end of C to the flat pole A, so that there is an excellent contact, I find the pull about 2½lb. Now try the round end of C on the flat pole, A ; the pull is about 3lb. The flat end of C on the round pole B is also about 3lb. But if now I put together two surfaces that are both rounded, I get almost exactly the same pull as at first with the two flat surfaces. I have made many experiments on this, and so have others. Take the following case :—There is hung up a horseshoe magnet, one pole being slightly convex and the other absolutely flattened, and there is put at the bottom a square bar armature, over which is slipped a hook, to which weights can be hung. Which end of the armature do you think will be detached first ?

If you were going simply by the square inches, you would say this square end will stick on tighter ; it has more gripping surface. But, as a matter of fact, the other sticks tighter. Why ? We are dealing here with a magnetic circuit. There is a certain total magnetic reluctance all round it, and the whole number of magnetic

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lines generated in the circuit depends on two things—on the magnetising force, and on the reluctance all round ; and, saving a little leakage it is the same number of magnetic lines which come through at B as go through at A. But here, owing to the fact that there is at B a better contact at the middle than at the edges of the pole, the lines are crowded into a smaller space, and therefore at that particular place B_n, the number of lines per square inch runs up higher, and when you square the larger number, its square becomes still larger in proportion In comparing the square of the smaller B_n with the square of greater B_n, the square of the smaller B_n over the larger area turns out to be less than the square of the larger B_n integrated over the smaller area. It is the law of the square coming in.

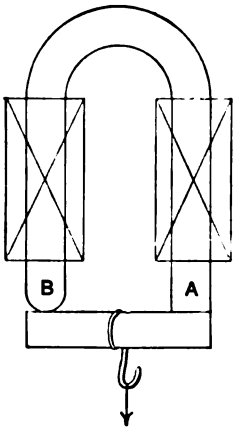

FIG. 25.—Experiment of Detaching Armature.

As an example, take the case of a magnet pole formed on the end of a piece of round iron 1·15in. in diameter. The flat pole will have 1 05 inch area. Suppose the magnetising forces are such as to make $B_n = 90300$, then, by Table VI., the whole pull will be 118·75lb., and the actual number of lines through the contact surface will be $N = 948150$. Now suppose the pole be reduced by rounding off the edge till the effective contact area is reduced to 0·9 square inch. If all these lines were crowded through that area, that would give a rate of 105630 per square inch. Suppose, however, that the additional reluctance and the leakage reduced the number by 2 per cent., there would still be 103500 per square inch. Reference to Table VI. shows that this gives a pull of 147·71b. per square inch, which multiplied by the reduced area 0·9 gives a total pull of 132·91b., which is larger than the original pull.

(To be continued.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *September* 26, 1890.

The Edison Company.—This Company has settled down to business under its new organisation, and is just now very prosperous. It has been determined by its managers to abandon the manufacture of the Sprague type of stationary motor. A machine built on the pattern of the Edison dynamo will be substituted hereafter for the Sprague in all Edison work. Whether the change will be an improvement or not can only be told after a sufficient number of the new machines have been put out. How far the Sprague street car motor will be altered under the Edison management it is hard to say ; but Mr. Edison has been vigorously engaged in making changes, and some new features are anticipated, among other things a single motor probably will be used in place of the two heretofore employed on street cars. This will undoubtedly produce an improvement in the matter of general efficiency.

Subways.—The difficulty between the Subway Company and the electrical illuminating companies is still vigorously under way. Charges of every description are flying about, and where nothing further can be said the attorneys of both parties indulge in vituperation. Mayor Grant, as usual, is ready for anything to interfere with the electric service of the city, and can be depended upon to stand in the way of the illuminating companies every time there is an opportunity. There seems to be no good reason why the companies should be compelled to put their wires in conduits, for which a most exorbitant price is charged. It is an unquestionable fact that conduits sufficient for the necessary service can be laid at a very small fraction of the alleged cost of the present structure ; in fact, the annual rental demanded would almost pay for a proper conduit. The result of this obstruction policy on the part of the City Fathers is to hinder the operations of the electrical companies very seriously, and it is no easy matter to find a way out of the difficulty.

Westinghouse Traction Work.—Good reports still continue to come from the Westinghouse electric cars, started in operation in various portions of the country, but no further details of the machinery have been made public. The system is being vigorously pushed, however, and I presume the apparatus will be given the public prominence it deserves in a very short time.

The Life of Lamps on Arc Circuits.—There have recently appeared a number of interesting reports of long life in incandescent lamps, but very little has heretofore been reported concerning the type of incandescent lamps used on arc circuit in series. A recent account of some practical experiments gives results that are decidedly encouraging. 230 30-candle power, 10 ampere, series lamps of the Bernstein make were placed on the circuit of the Electric Light and Power Company, of Elizabeth City, N.C. At the present time there have been less than 30 renewals, in spite of the lamps being run up to the full amperage all the time. The time of burning has averaged something over 1,500 hours.

Electrical Execution.—The electrical execution matter is again before the public by reason of the desperate efforts that are being made on behalf of a Japanese murderer, sentenced under the new law.

CORRESPONDENCE.

MAGNETO-OPTIC E.M.F.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : About two years ago it occurred to me to try whether the rotation of the plane of polarisation of plane polarised light inside a coil would generate either a continuous or an oscillatory current in the coil ; and, with the aid of three friends, I tried the experiment in the Physical Laboratory of this College.

The light of an albocarbon lamp was passed through a Nicol prism which was fixed on a shaft connected with a small turbine. The ray which emerged from the Nicol was passed through a glass tube filled with turpentine, which was placed in the axis of a reel of fine wire, the extremities of which could be connected either with a galvanometer or a telephone. The rotation of the plane of polarisation was produced by rotating the Nicol by means of the turbine.

When the experiment was first performed, we came to the conclusion that no result was produced either in the galvanometer or in the telephone. Last May I thought that it was worth while to repeat the experiment with more care ; but again there was no result to "swear by."

Dr. Sheldon appears to have performed a very similar experiment on a much greater scale ; but most of my scientific friends doubt his success, and, indeed, deny that we have any reason to expect such a result at all.

One scientific authority said to me as I was about to try the experiment, "You expect the converse of the result produced by passing a ray of polarised light through turpentine in a magnetic field ; and as we know that when polarised light passes through a sugary liquid, its plane of polarisation is rotated, conversely, if you take a beaker of water, let polarised light fall on one side of the beaker, and rotate the plane of polarisation, I shall expect to see tons of sugar coming out at the other side."—Yours, &c., GEO. M. MINCHIN.

R.I.E. College, Cooper's Hill, October 4, 1890.

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THE NEW MAGNETOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of September 26th you notice a communication which I have recently made to the Royal Society on a new magnetometer. You will be good enough to let me correct you on one or two points. Your statement that H is measured by observing the deflection of the needle at the centre of the circular magnet, and by observing the angle through which the upper end of the bifilars has to be turned to make the plane of the "circular magnet" E. and W., is incorrect. It could, of course, so be measured, but not, I think, so conveniently as by measuring the deflections of both needle and magnet from the N.S. and E.W. directions respectively, before and after reversal of the magnet.

Then you say that the correction for torsion of the suspending fibres is *rather serious*. In the paper referred to, I style this correction *utterly negligible*. It can, of course, be made serious by using a cable of silk; but by making the circular magnet very light (and I hope to be able to reduce it much below 11 gms. in the more elaborate instrument I am designing), and suspending it bifilarly by an ordinary cocoon fibre, the correction for torsion with a 30cm. suspension is *utterly negligible* (*see* Gray, *Phil. Mag.*, January, 1887). The correction for torsion suspension of the little needle is much more serious, and with a coarse fibre may easily amount to 1 in 1,000. It can, however, readily be allowed for by turning the needle through 360°, and re-observing its position after the ordinary fashion.

In connection with the employment of a bifilar suspension to measure a horizontal couple absolutely, may I remark that while the measurements are necessarily somewhat rough with wire suspensions, unless these are of gigantic dimensions—dimensions tolerable only in German laboratories—the measurements can be made with the greatest ease and simplicity, certainly to 1 in 1,000, and I hope to be able to show, experimentally, to 1 in 10,000, provided the body is so light that a single cocoon fibre will support it bifilarly.

If any of your readers should be employing the method, may I just mention the one point to which slight attention must be devoted, viz.: the magnet must be so supported from the silk fibres that their tensions are roughly equal. A difference in tensions of 5 per cent. of the whole weight supported will make the observation of H too large by 1 in 800. A similar difference of 1 per cent. will affect H to the extent of 1 in 20,000, so that the adjustment of approximate equality of tensions need only be rough for one-tenth-per-cent. work. It should be mentioned that the observations referred to in the *Proc. Roy. Soc.* were made *without care being taken on this point*, because I relied upon the extensibility of the silk fibres to automatically adjust the tensions to sufficient equality. This is one of the points, I think, in favour of silk as a material for bifilar suspension. Of course, a smooth pulley, supported in frictionless bearings at the top of the instrument, and over which the silk fibre passes, perfectly satisfies the condition of equality of tension in theory. In preference to this, the arrangement which I should recommend is to attach a little hook at the middle of the wide hook under which the lower end of the bifilars pass, and to lower the weight on to the fibres by means of a loop of thread attached to this hook and afterwards removed.

One other point should be noticed, viz., that copper pieces should be attached to the vertical sides of the box to damp the oscillations of the magnet.

In conclusion, may I ask your readers to compare the formula for H in the case of the New and Kew instruments respectively? In the one case we have

$$H^2 = \frac{W\,d\,d'}{4\,l\,r^3}\,\frac{\tan\theta\cos(\phi-\theta)}{\sin\phi},$$

and there is no correction for anything except possibly a temperature correction for differential metallic expansion, which, as is well known, can be made exceedingly small in a bifilar arrangement. In the case of the Kew the formula is—but I forbear. Those of your readers who are interested in magnetometry will not have forgotten it, although they certainly will not remember all the minutiæ of its ramifications.—Yours, &c.,

WILLIAM STROUD.

The Yorkshire College, Leeds, October 4th.

THE SYPHON RECORDER AND THE D'ARSONVAL GALVANOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following Note appeared in *The Electrician* of July 18, 1890:—

"Whilst describing Sir William Thomson's syphon recorder, Dr. Walmsley made incidentally a remark which will be endorsed by all English electricians. He drew attention to the fact that the D'Arsonval galvanometer, about which we have heard so much during the last few years, is nothing else but a revival of the corresponding part in the syphon recorder, and that it therefore should properly be called the Thomson galvanometer. The wonder is that the similarity between the two instruments has not been pointed out before. The arrangement of a coil suspended between fixed poles and an inner soft iron fixed armature is, as Dr. Walmsley points out, to be found in Maxwell."

With regard to this interesting note, might it not be suggested that the similarity of the suspended coils of the D'Arsonval galvanometer and the Thomson syphon recorder has not been made a subject for special comment, for the reason that the likeness between the two is obvious? Is not Dr. Walmsley's stricture on the naming of M. D'Arsonval's galvanometer somewhat severe? If the latter gentleman has been the first to adapt the suspended coil to testing instruments, is it not but fair that the adaptation be named after the adapter? Sir William Thomson, in his syphon recorder, made use of the suspended coil—a contrivance already known. The "Mouse Mill" also was a modification, through a series of beautiful developments, of Varley's influence machine. In fact, the only novelty in the syphon recorder lay in the electrical spirting of the ink on to the paper band, a device now being superseded by the vibrator. Yet who will deny that the recorder—taken as a whole, an ideal of delicate adjustment and mathematical exactness in detail—was a genuine invention of the first order, and how grossly inaccurate it would be to speak of this combination of solved difficulties as anybody else's but Thomson's, even now that electrification is yielding the *pas* to the vibrator, and the mill to the simple motor, or to the still more prosaic clockwork.

Now, if a Thomson can utilise the suspended coil, why should not M. D'Arsonval be free to do the same when he constructs a galvanometer? And why should his instrument be named after Thomson, as Dr. Walmsley suggests. Sir William Thomson's great name is already associated with his own modification of and improvement on Weber's mirror galvanometer. Weber's instrument, with its heavy and sluggish magnetised steel mirror, could not well have benefited cable telegraphy, but was nevertheless the embryo which, under the treatment of a master mind, developed in one direction into the Thomson speaking mirror, and, in another, into the Thomson astatic mirror galvanometer, a familiar object in all electrical test-rooms.

A point worthy of the beginner's attention is that the movable coil between fixed magnetic poles, as an example of magnetic attraction and repulsion, is an exact opposite to Oersted's wire and needle, and to all the subsequent developments of this arrangement down to Thomson's galvanometer. Besides these two classes there are two others, in the first of which a movable coil is influenced by an inner fixed coil, whilst in the other an outer fixed coil influences an inner movable one. It happens that four well-known testing instruments exemplify all four classes, namely:—(1). Movable coil between poles, of fixed magnet: D'Arsonnal's galvanometer. (2). Movable magnets within fixed coil: Sir William Thomson's galvanometer. (3). Fixed coil within movable coil: Siemen's electro-dynamometer. (4.) Movable coil within fixed coil: Prof. Elihu Thomson's electric meter.

Owing to the complete analogy between a magnet and a current-traversed wire—so beautifully shown by Ampère—we can speak of current-traversed wires as wire magnets, and describe our four classes of instruments as follows:—(1) Movable wire magnet within fixed permanent magnet; (2) Movable permanent magnet within fixed wire magnet; (3) Fixed wire magnet within movable wire magnet; (4) Movable wire magnet within fixed wire magnet.

Explanations of electro-dynamical effects, such, for instance, as the above, are greatly simplified for beginners by treating current-traversed coils purely and simply as magnets, the two

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faces of the coil being the poles, which vary in sign, with direction of traversing current. There are at least seven text-books, which describe the syphon recorder, but which, when treating of the suspended coil remain, one and all, content with the statement that a current through it causes it to be "impelled across the magnetic field in one direction or the other, according to the polarity and strength of the current passing throught it," or words to the same effect, as if this movement were some phenomenon too complicated for brief explanation. It may be that readers of these books are expected to know the elements of electro-dynamics before they study instruments in detail; but in practice, junior students—probationers at a submarine cable station, for instance, who have not much time for theoretical work—will want to understand their instruments without too close a study of Ganot or Deschanel, or without even patient perusal of earlier chapters in electrical text-books. Now, once the beginner realises that a current-traversed coil is practically a magnet, the *rationale* of all deflections becomes to him self-evident.

This suspended coil question is of special interest to the writer of this letter, who in 1887 successfully adopted this device in connection with a cable mirror, and a short account of which he hopes shortly to publish.—Yours, &c.,

Madeira, September, 1890. E. RAYMOND BARKER.

LEGAL INTELLIGENCE.

Watt v. Maxim-Weston Company (Limited)—Maxim-Weston Company (Limited) v. Watt.

On Wednesday morning, before Mr. Justice Vaughan Williams, sitting in the Chancery Division of the High Court of Justice, Mr. E. Morten applied *ex parte* in the above actions, which would shortly come before Mr. Justice North for trial, for an order for the examination of a witness before a special examiner. The actions involved a great many issues, one important thing being to unravel the dealings which had taken place in the shares of the Company at the instance of Mr. Watt, Chairman of the Company. For this purpose it would be necessary to have the evidence of the stockbroker who carried out the transactions on the Stock Exchange for Mr. Watt. Information had been just received that Mr. Barnard, the stockbroker in question, was about to depart for America in search of sport, which was likely to keep him there for the next six months. That being so, it was desired to take the examination early next week. In the case of Bidder *v.* Brydges, the Court had held that such an order would be made where necessary for the purposes of justice.

His Lordship said he was somewhat loth to make the order *ex parte*, but he would do so upon conditions. It was quite plain the examination could not be conducted effectively unless the other side had notice and the opportunity of being present. The order would go, but would contain upon its face the condition that notice should forthwith be given to the other side, and that they should be at liberty to apply to discharge the order.

Woodhouse and Rawson (Limited).

A motion for the removal of the liquidators of this Company, for the appointment of others in their place, and to restrain further dealing with the assets, was also in the list for hearing; but Mr. Baker stated that, by consent, it had been arranged that the motion should be withdrawn from the paper, no order being made upon it. His Lordship acceded to the application.

TRADE NOTES AND NOTICES.

[Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.]

TENDERS WANTED.—The Controller of Stores of the General Post Office invites tenders for the supply of red fir telegraph poles, and also for creosoting the same. Particulars of the conditions of the contract, &c., will be found in our advertisement columns, and forms of tender and all particulars may be obtained of Mr. Chas. E. Stuart, the Controller of Stores, Telegraph-street, E.C. Tenders must be in by noon on Friday, October 31st.

———Tenders are invited by October 15, 1890, for the supply of 5,000 kilogrammes of phosphor or silicium-bronze telegraph wire for the Telegraph Administration of Stockholm and Gothenburg. The diameter of the wire is to be 1·25 mm.; conductivity 30 per cent. of that of pure copper, and the tensile strength 80 kilogrammes per square millimetre. Offers, with price and conditions, are to be marked "Aubud á leverans af fosforeller silicium bronstrad."

TENDERS.—The Corporation of Dublin give notice that the time for receiving tenders for the electric lighting of the Dublin streets, &c., has been extended from the 13th October to 5 p.m. on the 30th October.

———An official intimation reaches us from Stockholm notifying that an error was made in the advertisement referred to in our editorial note of September 19, as to the time when tenders would be received for the erection of the central station at Stockholm.

SALES BY AUCTION.—On Tuesday, October 21st, Messrs. Wheatley Kirk, Price, and Goulty will sell by public auction, at the Drogheda Engineering Works, Drogheda, Ireland, at 10 for 11 o'clock prompt, the extensive premises, plant, fixtures, &c., of the business lately carried on by Messrs. Thomas Grendon and Co. The works are very extensive, and the buildings include substantial and extensive general drawing and private offices; heavy and light iron foundries; boiler and girder shops; turnery, erecting, pattern-making, and other shops; stores, brass foundry, &c. The contents of the Works include numerous overhead, travelling, portable iron and timber jib cranes; timber shear legs; sliding, surfacing, brake, screw-cutting, hand and other lathes; boring, planing, drilling, slotting, shaping, screwing, plate and and angle-bending, punching, shearing and other machines; steam rivetter; new stores; steam hammers; tools and utensils for several hundred hands; office furniture, fittings, and other effects. Included in the sale is also the schooner-rigged iron sailing vessel "Mouse," length 69·6 feet, breadth 16·1 feet, depth of hold 7·05 feet, with a cargo capacity of 75 tons. Further particulars are given in our advertisement columns, and full particulars and plans can be obtained gratis of the Auctioneers, 52, Queen Victoria-street, London, E.C.; and Albert-square, Manchester; or at the Works.

PRICE LIST.—The Electric Construction Corporation have issued a very handsome catalogue of their manufactures, with complete lists of their different types of accumulators, dynamos, transformers, instruments, switches, switchboards, &c. The tables showing the output, number of revolutions, and price of the dynamos are very conveniently arranged, facilitating the selection by offering for any particular output several sizes of dynamos at different speeds.

THE JOHNSON STORAGE BATTERY.—This battery, we are informed, has the active material suspended in a net-work of lead, and is said to have a capacity of 10 ampere hours per pound of element. These batteries are used on the Union Electric Car Company's tramways. A 21-lb. cell is reported to have been tested for two hours and ten minutes' continuous work, including twenty-three minutes' discharge at 100 amperes, the volts dropping from 2·05 to 1·67. A number of these cells were charged in Boston, and have been sent to this country, but it is difficult to see what interest attaches to their discharge in Westminster.

A NEW CUT-OUT.—As a rule we do not care to notice a cut-out of which we have not seen a sample; but the illustration and description of the Champion Cut-out is sufficient to condemn it in our opinion, since it is intended to be hidden away in ordinary wood casing, a most improper position, and makes use of vulcanised fibre, a most unsuitable material.

KOMMANDITGESELLSCHAFT W. LAHMEYER AND CO.—Under this title a company has been formed in Frankfort-on-the-Main, with a capital of 1,200,000 marks, to carry on the business of electrical engineers. The new firm will manufacture the larger dynamos of Messrs. Garbe, Lahmeyer, and Co., of Aachen, with which Company it will act on friendly terms.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

September 17, 1890.

14,666. J. CHARTERS. Glasgow. Improvements in electric switches.

14,679. W. WILKINSON and W. A. SYKES. Halifax. Improvements in electrical alarm apparatus for shops, stores, and other purposes.

14,686. W. R. LAKE. London. Improvements relating to the preparation or treatment of carbons for electric lamps or lighting apparatus (Lacombe and Co., France).

14,693. J. P. BAYLY. London. Galvanic battery (José Siliceo, Mexico).

14,696. J. P. BAYLY. London. Improved telegraphic relay (J. M. Treber, United States).

14,698. R. E. B. CROMPTON and W. A. CHAMEN. London. Improvements in conductors for the distribution of electrical energy, and in apparatus connected therewith.

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September 18, 1890.

14,748. P. WILLIAMS. London. Improvements in apparatus for electrically giving alarm from letter-plates, post boxes, and other purposes.

14,755. H. EDMUNDS. London. Improvements in or connected with the production of wires, rods, or other forms of metal by electro-deposition.

14,776. C. T. J. VAUTIN. London. An improved process and means for the electro-deposition of metal.

September 19, 1890.

14,807. J. GUEZDA. London. An improvement in the supply of electricity in medical cases.

14,817. R. KENNEDY. Glasgow. Improvements in and relating to the distribution of electrical energy.

14,819. E. DE PASS. London. Musical instruments termed "Electro-magnetic Palsiphones" (C. E. Guerre and J. H. Martin, France).

14,830. F. WALTON. London. Improved means of accommodating electric wires in buildings.

14,844. J. APPLETON and E. L. JOSEPH. London. An improved electrical connecter.

September 20, 1890.

14,848. F. SMALLWOOD. Birmingham. Electric push or press, with or without letters on plunger thereof, to prevent, in use, same getting out of required position.

September 22, 1890.

14,927. G. MACAULAY-CRUIKSHANK. Glasgow. Improvements in telephones (E. B. Welch, United States).

14,974. W. T. GOOLDEN and S. EVERSHED. London. Improvements in electric meters.

September 23, 1890.

14,992. W. C. C. HAWTAYNE. London. Improvements in the construction of underground conduits for electrical conductors.

15,006. R. KENNEDY. Kilmarnock. Improvements in converting electrical energy, and in apparatus therefor.

15,043. W. R. LAKE. London. Improvements in electric heating apparatus (E. Abshagen, United States).

15,054. S. O. C. COLES. London. Improvements relating to the electro-deposition of metallic alloys.

15,061. J. TELLEFSEN. London. Improvements in electrical apparatus for the prevention of corrosion and formation of scale in steam boilers.

September 24, 1890.

15,084. C. J. VAN DEPOELE. London. Improvements in electric railway conduits with tubular conductors. (Date applied for under Patents Act, 1883, section 103, May 22, 1890, being date of application in United States.)

15,114. G. C. FRICKER and J. R. BAINTON. London. Improvements in the manufacture of plates for secondary batteries, and in the construction of such batteries.

September 25, 1890.

15,153. W. J. S. BARBOUR-STARKEY. Manchester. Improvements in separators for galvanic batteries.

15,186. W. S. FROST. London. Improvements in electric rotary hair-brushes and apparatus.

15,187. W. S. FROST. London. Electric shampooing and bathing apparatus.

15,191. C. PAUTHONIER and L'INCANDESCENCE ÉLECTRIQUE SOCIÉTÉ. London. Improved process or method of renewing flexible carbon filaments in glow or incandescent electric lamps.

15,203. H. H. LAKE. London. An improved socket for incandescent electric lamps. (J. S. Potter, United States.)

15,221. P. R. DE FAUCHEUX D'HUMY. Liverpool. Improvements in the production of electric currents by means of air or water for lighting steamships and railway trains, and for other purposes.

15,248. W. B. SISLING, W. H. SCOTT, and L. SCOTT and CO. (LIMITED). Norwich. Improvements in dynamos and electric apparatus for charging accumulator cells and running lamps at the same time.

SPECIFICATIONS PUBLISHED.

1889.

13,960. SHEPARD. Measuring electric currents, etc. (Price 8d.)

14,113. IMMISCH. Electrical switches. (Price 11d.)

14,114. IMMISCH. Electrical tramcar switch. (Price 11d.)

14,447. THOMPSON (Bemis and another). Electric rail, etc., cars. (Price 8d.)

15,449. GLOVER. Electrical cables. (Price 6d.)

16,599. ADAMS-RANDALL. Electric date, etc., stamps. (Price 1s. 1d.)

16,747. JOHNSON. Coupling and supporting wires, etc. (Price 8d.)

17,317. GOOLDEN EVERSHED. Electric measuring, etc., apparatus. (Price 8d.)

18,343. SIEMENS BROS. and Co., Limited (Siemens and Halske). Electrical conductors. (Price 8d.)

1890.

10,124. DEWEY. Electric heating apparatus. (Price 8d.)

10,179. HADDAN (Spalding). Telephone call devices. (Price 6d.)

COMPANIES' MEETINGS & REPORTS.

Woodhouse and Rawson (Limited).

An extraordinary general meeting of the shareholders of this Company was held yesterday afternoon at Worcester House, Walbrook, E.C., and not at 11, Queen Victoria-street, as stated on the notice. The Press were refused admission; but we understand that Sir John Stokes presided, and apologised for the change of the place of meeting, and spoke generally of the labours and troubles and energy of the liquidators. The assets were more favourable than was thought. Liquidation had been delayed by (1) founders (2) by arbitration, and had lasted more than one year instead of three months. No time or labour spared. The liquidation had been pushed on so as to secure the dividend shortly to be announced by the United Company, and it was hoped that the shareholders would now obtain this dividend, which was in respect of working up to June, 1890. Further details he would not go into.

A dissentient shareholder asked what his position was, and wished for more detailed information. He was told that he would get his capital back in cash, and nothing else—no dividend and no interest.

The shareholders are to receive scrip of Woodhouse and Rawson United at par, with 15 per cent. bonus, in the proportion of three ordinary and two Preference shares.

In reply to the demand of a Shareholder, it was promised that a copy of the accountss hould be furnished at the close of the liquidation.

The remuneration for the services to the old Company by Mr. Hoster and Mr. F. L. Rawson were discussed. The latter asked for £12,000, but, after discussion, it was decided to award £10,000.

It will be remembered that in July, 1889, the Woodhouse and Rawson Company, in conjunction with several sub-companies, were consolidated into a new Company, called the Woodhouse and Rawson United (Limited). The profits, which at that time were said to belong to and have been earned by the old Company, amounted to £75,000; and, in spite of this, no dividend whatever was paid for the year 1388-9. The profits having been pledged to the new Company to guarantee a dividend of 15 per cent. on their ordinary shares, the shareholders were promised shares in the new Company equivalent to the shares which they held in the old Company. But since the United Company was formed in July, 1889, the shareholders in the old Company have received no scrip and no dividend of any sort. Dividends at the rate of 15 per cent. have been half-yearly declared in favour of the United Company (possibly out of the guarantee fund belonging to the old Company), but in spite of this not one penny has been paid to the shareholders in the old Company.

The International Okonite Company (Limited).

The statutory general meeting of the members of this Company was held yesterday, at the Cannon-street Hotel, Cannon-street, "for the transaction of the general business of the Company." The chair was taken by Mr. Samuel Pope, Q.C.

The SECRETARY (Mr. P. J. Bordessa) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, in the absence of our chairman, Lord Greville, who is in Ireland, it becomes my duty as deputy-chairman to take the chair at this the statutory meeting. You are aware, of course, that the law compels a company to hold a meeting of this sort at all events within four months of the date of its registration. Business at such statutory meetings is generally of the most formal character, because, of course, no report and no balance-sheet is possible in the limited period in which the Directors have had control of the undertaking. But our articles also fix that our first general meeting shall be held within the statutory period of four months; and my colleagues have, therefore, thought it desirable that we should not treat this meeting as of the purely formal character which a statutory meeting ordinarily is; but that we should meet the desire of many of our shareholders, and state exactly what has been done since we came into office, and the prospects which we think the undertaking affords for future development. Now, gentlemen, you know that our capital was originally fixed at the sum of £440,000. It was divided into £170,000 worth of £10 Preference shares, £170,000 worth of £10 Ordinary shares, and £100,000 of £100 Debentures, making a total of £440,000. Of this amount £113,330 was paid to the vendors as vendors' shares and £33,300 of Debentures. That left, as you will see if you work it out, £226,670 of Preference and Ordinary shares as the balance to be allotted to the various applicants. Of that amount of £226,670 the whole has been fully subscribed without a single share having been underwritten. Now of the Debentures, out of £66,700—the balance of the £100,000, deducting the £33,300 to be allotted to the vendors—there has been taken up £51,700, leaving a balance of £15,000, the only balance unallotted of the entire capital, which it is our intention not to allot until we require the money. You may therefore take it that our capital account is summed up in the description that the whole capital has been subscribed for and allotted with the exception of £15,000 of Debentures, which we do not require to allot, and which, it seems to us, it would be folly to allot until we want the money. Our Managing

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Director and Mr. Connolly, our works manager, have visited the United States since the incorporation of the Company for the purpose of examining into the business, and technical working of the factory at Passaic, New Jersey, and to learn the special processes carried on there for the purpose of erecting similar plant at our Manchester works. The Managing Director has returned, and Mr. Connolly is on his way home. The Managing Director reports—and I believe Mr. Connolly agrees with him—that the works are in first-class order, well organised, admirably arranged, and fully occupied. If the turn-out from the factory for the year 1887 be assumed at the unit 100, then the turn-out in 1888 represented 164, in 1889 244, and for 1890, so far, at the rate of 450, a satisfactory figure. In other words, our investigation has shown that the output at our American works has become four and a-half times what it was in 1887. Now, in addition to the vendors' shares named in the prospectus, the Directors who form the American Committee have subscribed for considerably over £60,000 in shares, paying for them in the ordinary and usual way. The title to the American factory has been fully examined and approved by our solicitors, Messrs. Davies, Short, and Townsend, of New York. The whole of the purchase-money has been paid, and the property in America has been vested in the Central Trust Company of New York as trustees for the Debenture holders. From personal inspection, our managers report that they are satisfied that the business is a sound and lucrative one, with every prospect of a large and continual increase, and that there is an immense advantage in having a factory both in New York and at Manchester. With regard to our Manchester works, the business has been taken over and paid for, and we have since acquired a plot of vacant ground of about one acre, bounded on one side by our own factory, on another by the Rochdale Canal, and on the other two sides by good roads. On this we are at present erecting, and are actively pushing on, an important fireproof factory for the manufacture of our speciality of high-class okonite wires and cables, and the necessary machinery is well in hand. The works are in full swing, manufacturing various classes of insulated wires, and orders are coming in most satisfactorily. Messrs. Shaw and Connolly have agreed to serve the Company for a term of years; and as both these gentlemen have great technical and business knowledge—second to none, I may say—in the manufacture of insulated wire, we have every reason to anticipate that, with the capital at our command, our English business will soon rival, if it does not exceed, our American. Certain statements as to the profits of the year were made in the prospectus which was issued to the shareholders, and some shareholders have questioned the profits for 1889 and 1890 of Messrs. Shaw and Connolly, which were taken as estimated and not ascertained, of the old Okonite Company, these profits not having been ascertained by a competent accountant at the date of the prospectus. We are, however, now in possession of Messrs. Price, Waterhouse, and Company's report; and the statements made of estimated profits in the prospectus are well under the actually ascertained amount. I should, however, say, with respect to the profits of 1890 of the old Company in America, that we have not yet got Messrs. Price and Waterhouse's certificate. We cabled to New York in order that we might have the most recent information as to the progress of the audit, for, of course, we thought it desirable, as soon as we came into possession of the property, that we should ascertain, as far as we could, the actual facts with respect to it. We have received from the New York office, under date of September 26th, a letter in which they say:—"We have not got our books quite closed yet. Approximately, I think the profits will be considerably larger than we claimed they would be on the prospectus." But, as I say, we were anxious to put before you, if we could, not merely a confirmatory statement by the vendors, but the actual result of investigations, and we cabled yesterday for such results. I do not think we have yet received the certificate, but from what our general manager tells us he ascertained there, I think there can be no doubt that both these statements will be abundantly justified by the facts when we come to make them out. I have very little more to say, because, of course, we can have had no great experience in the management of the concern during the short period we have been in office. I think I may say, however, that the view which my colleagues, and which, I am sure, I myself, would desire to see carried out, would be to manage this concern with an eye to make it a substantial commercial undertaking—not with a view merely to create a temporary fictitious value in the shares of the Company, but with the view, if possible, of developing a commercial enterprise in a legitimate and commercial way. Now, during the last three years of the Okonite Company's working they never had returned to them a single yard of okonite wire as being defective in insulation. The whole of the wires are guaranteed to a standard far in excess of working requirements, and are tested fully 100 per cent. over our guarantee before they leave the works. We shall adopt the same system in England, as, although it tends slightly to increase the cost of production, it is so important to have electrical insulated conductors of high-class which can be relied upon with absolute confidence that we feel we cannot make our Okonite wire too good. The scrip certificates have been issued, and application has been made to the Stock Exchange for a special settlement and quotation in their official list; and for this purpose the whole of the necessary papers have been sent into the Committee. Your Directors do not entertain any doubt that in a very short time their request will be complied with, and the shares of the Okonite Company will appear in the official list of the Stock Exchange. That is all I think I can say at this meeting, unless any shareholder desires further information; and if anything occurs to him upon which he would like to put a question, it shall be answered with as much frankness as I hope I have laid this statement before you. He added: As a commencement—or hardly a commencement—but as showing that we are active in our English business, the Managing-Director has put into my hand an order which we have just received for 135,000ft. of Okonite wire from an English firm.

Mr. J. B. FERRIER (Cardiff) expressed his satisfaction with the statement which the Chairman had made. There had been some criticisms in a financial organ, but he did not know that it was of much standing. He had been induced to take his shares in the Company through the connection with it of Lord Aberdare and Mr. Pope.

Mr. W. JOHNSON (York) said that a friend of his had thought it very curious that the six or seven gentlemen whose names appeared to the Memorandum of Association only held one share each.

The CHAIRMAN: I am afraid if your friends had been accustomed to dealing with joint-stock Companies they would know that in every case the Memorandum of Association is signed for one share each, whatever the gentlemen concerned may ultimately take. That is the usual thing.

Mr. JOHNSON asked whether it was legitimate or usual for the remuneration of the Directors to be fixed before the meeting of the shareholders.

The CHAIRMAN: The Directors' remuneration is frequently—generally, in fact—fixed in the Articles of Association.

Mr. JOHNSON said he had been told that it was generally fixed by the shareholders attending the ordinary meeting.

The CHAIRMAN said he did not think that that was the usual course.

A SHAREHOLDER: It is a great deal more often the other way.

The CHAIRMAN: No doubt it is sometimes arranged by a vote of the shareholders, but, generally speaking, especially in Companies like this, which involve a great deal of personal labour, the remuneration is fixed. Otherwise you would not get gentlemen of experience to sacrifice their time. I do not intend to say a word about the financial paper that has been mentioned. I am sure our friends in the country will understand that criticisms are frequently made for the purpose of acquiring notoriety; and I do not intend to contribute to that notoriety in this case. At this particular meeting there can be no resolution submitted, and, therefore, I am anxious, if possible, to encourage shareholders to disburden their minds of anything they may have upon them. If, however, no other gentleman has anything to say, that will necessarily close the proceedings of the statutory meeting; and with your permission we will now resolve ourselves into an extraordinary general meeting.

The SECRETARY read the notice convening this meeting, which was to consider the confirmation of the subjoined resolution, which was passed at the meeting on the 10th ult.:—

"*That the Articles of Association of the Company be altered in manner following:—*

"*(a.) In Clause 35, that the portion of the clause following the words 'provided that' be struck out and the following inserted: 'The funds of the Company shall not be expended in the purchase of or lent upon the security of its own shares.'*

"*(b.) In Clause 72, that the following words be added at the end of the clause: 'And unless he shall do so, he shall be deemed to have agreed to take the said shares from the Company, and the same shall be forthwith allotted to him accordingly.'*

"*(c.) In Clause 116, that the following words be added at the end of the clause: 'And a copy of such balance-sheet shall be posted to each member at his registered address at least eight days before such ordinary general meeting.'*"

The CHAIRMAN: The object of the special resolution is to make certain minor changes in the Articles of Association, which are called for by the Committee of the Stock Exchange; and, of course, it is necessary that we should make our articles conform with their rules and wishes, seeing that we are applicants to them for a quotation in their official list. I will now move the confirmation by this meeting of the resolution which was passed by the extraordinary general meeting referred to in the notice.

Mr. H. H. DOBREE seconded the resolution, which was carried unanimously.

A vote of thanks to the Chairman brought the meeting to a close.

Woodhouse and Rawson United (Limited).

The following is the annual report of the Directors of Woodhouse and Rawson United (Limited), for the year ended 30th June last, to be presented at the general meeting to be held at Winchester House, E.C., to-day (Friday), the 10th instant, at 12 o'clock:—

Of the original capital all the ordinary and Preference shares have now been issued. Of the ordinary shares one-half of their value remains uncalled. The premiums from the second issue, amounting to £4,050. 5s., have been placed to a reserve fund. From the balance-sheet which accompanies the report, it will be seen that after payment of all expenses and writing off £7,421. 16s. 9d. in reduction of the sum standing to patent account, the balance to the credit of the Company amounts to £61,085. 1s. 9d. Out of this sum the Directors propose to pay a dividend at the rate of 15 per cent. per annum on the ordinary shares and of 8 per cent. per annum on the Preference shares, which, together with the interim dividend for the half-year already paid at these rates, amounts to £18,749. 6s. 6d. Of the balance, amounting to £42,335 15s. 3d., the Directors propose to place to reserve £25,000, of which £10,000 will be set aside to a goodwill reserve fund and £15,000 to a general reserve fund, and to apply £1,000 to the formation of an Employés' Pension Fund, leaving £16,335 15s. 3d. to be carried forward to next year's account. The Directors do not propose to increase the dividend anticipated in the prospectus, as the prudence of building up reserve funds ot a considerable amount will be evident to the shareholders.

The Directors think it well on this occasion to give more information than is usually contained in an annual report, in order to enable the shareholders to realise the scope and extent of the operations in which the Company is engaged. Their efforts during the past year have been directed to consolidating and extending the several branches of business which have

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been taken over by the Company. These are of a very comprehensive character, and include—

1. The manufacture of all articles connected with electricity and engineering, so far as they can come reasonably within the technical and financial resources of the Company.

2. The supply of all articles connected with electricity and electrical engineering.

3. The execution of all works of installation coming within the province of electrical engineers and contractors.

4. The testing and proving of new patents and inventions connected with electrical and engineering science, and their introduction to the public, either by arrangements for working such inventions by this Company, or by assisting the owners in forming separate companies for working them.

The experience of the past year leaves no doubt that great services may be rendered to the shareholders and to the public by developing this latter branch of the business, with prudence and energy; and the knowledge acquired from an extensive range of manufactures, and a thorough acquaintance with the demand and channels of supply of electrical plant and apparatus, place this Company in an exceptional position to invite and secure the confidence of inventors, and to assist them in bringing their inventions before the public. With this object it is necessary to command the ready means of practically testing every kind of electrical and mechanical invention which may be offered, and to maintain an extensive business and correspondence in all parts of the world.

The following are the factories owned by the Company and the character of the work done:—

(*a*) West Kensington Hall Works, Hammersmith-road, W.—These works, over an acre in extent, are the Company's freehold. Here are manufactured light goods, such as switches, lamps, measuring and other electrical instruments, primary and secondary batteries, and every class of small automatic machinery. Here also is carried on the electro-plating business and manufacture of plating plant. At these works most processes offered to the Company are tested, and only when they have thoroughly passed the examination of the Company's experts is the purchase or introduction to the public entertained. At the present moment four important electrical inventions of exceptional merit are undergoing the process of final testing.

(*b*) Union Foundry, Kidsgrove, near Crewe.—These works, which are also freehold, have been recently acquired on advantageous terms, and are well situated in the heart of the coal and iron district, having both a railway sliding and a canal adjoining. They are fitted up with every class of heavy machinery to enable the Company to construct engines and boilers of almost any size or power, water and gasworks, plant, steam and hydraulic cranes, tanks, pumps, large dynamos and other heavy machinery, whilst further special plant is now being erected to keep abreast of recent improvements.

(*c*) Cornbrook Telegraph Works, Manchester.—These works are leasehold, and are fully engaged in the manufacture of telegraphic instruments; there are also manufactured small dynamos and motors, as well as light lathes and drilling, shaping, milling and screwing machines, specially designed for electrical work. Practically the whole of the contracts for telegraphic instruments, &c., for the London and North Western Railway for a period of two years, together with contracts for the Caledonian and Great Eastern Railway Companies, have been placed with the Company at these works.

(*d*) The supply department is rapidly increasing its turnover. Its catalogue of electrical goods and appliances connected therewith is recognised as the most complete and comprehensive of its kind, and forms a standard text-book in the trade. The acquisition of the new warehouse, with entrance at 30, Cannon-street, and more recently of the lease of the neighbouring premises at 34, Cannon-street, and 84, Queen Victoria-street, enables the Company to keep in hand and exhibit an extensive stock of nearly every kind of electrical apparatus and fittings.

(*e*) The Installation Department has carried out a large number of important contracts. Among others, the lighting of the Palace at Mysore, India, by electricity has been satisfactorily and profitably finished; and the Sociedad Española del Electricidad, in Barcelona, has placed the whole of their arrangements for improving and extending the lighting of that city by electricity in the hands of this Company.

(*f*) At Bradford the Company have a branch establishment with showroom and warehouse, which provides for installatiens and the supply of electrical goods in the North of England. The Company has been specially appointed contractors to the local authorities in that town in connection with their central electric lighting station.

(*g*) An electric bell and signalling business is conducted at 2, Gray's Inn-road, under the management of the Messrs. Jensen, whose well-known patents this Company has acquired.

(*h*) The Company has also acquired the electric and steam launch business of Mr. Sargeant, carried on at Chiswick.

Branch offices have been opened during the year in Sydney, Melbourne, Johannesburg, and Valparaiso, besides additional agencies in various other foreign countries.

In the early part of the present year the Directors disposed of a portion of their premises at West Kensington to the Kensington Co-operative Stores, Limited, a new Company, which obtained the support of this Company because it afforded an opportunity of disposing, upon advantageous terms, of a portion of its buildings unsuitable for manufacturing purposes, and increased the value of the remainder of the property. A second issue of shares of the Kensington Stores has lately been made at a large premium, and was applied for two and a-half times over.

The Directors have, in addition, been instrumental in forming the International Okonite Company, for the working throughout the world of the patents for that valuable insulating material. The Company, whose shares have been entirely allotted, has an established business in America of a profitable and rapidly increasing character; and owns works also at Manchester, from which it will supply the Okonite wire required in Great Britain. The yield of both the American and English works during the current year has largely increased, and a profitable return may be looked for.

This report would not be complete without an allusion to the success that has attended the introduction by Woodhouse and Rawson, Limited, of the now well-known Elmore process for manufacturing copper articles by electro-deposition at a great saving of cost, and of unique quality. Since the expiration of the financial year ending on June 30, 1890, this Company has introduced Elmore's French Patent Copper Depositing Company with very marked success; 66,750 shares were offered for subscription, and over 250,000 shares were applied for.

The official quotation of the shares of this Company in the Stock Exchange list is now before the committee. Owing to the delay in the winding-up of the Vendor Companies, mainly caused by the protracted arbitration in which one of them was engaged at the time of purchase, a final settlement with them had not been effected before the close of the first financial year of this Company. These difficulties have since been removed, and the Directors daily expect to have the quotation granted.

The sum of £75,000 which, as stated in the prospectus, Woodhouse & Rawson, Limited, was to lodge with this Company as a guarantee fund for the payment of a minimum dividend of 15 per cent. per annum for the first three years, has been duly received.

The shareholders will doubtless approve of the formation of an Employés' Pension Fund, which will tend to the retention of those employed by the Company, by requiting faithful services when age, failing health, or other causes necessitate their temporary or permanent withdrawal from the Company's employ. The amount proposed to be placed to the credit of this fund, though comparatively small for the purpose intended, will form a nucleus to which, in future, as the Company's success is con-

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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solidated, larger sums may be allocated. A resolution to give effect to this proposal will be submitted to the meeting.

The Directors feel that the shareholders owe a great deal to the various members of the staff for devoted services rendered, regardless of personal comfort and hours of labour, and especially to the Managing Director, Mr. F. L. Rawson, to whose zeal, enterprise, and judgment the results obtained in this the first year of the Company's operations are mainly due.

By the Articles of Association two Directors retire. The two who retire are Lord Aberdare and Sir Rawson W. Rawson; the latter, being eligible, offers himself for re-election; the former from impaired health and enforced absence from London, does not offer himself for re-election. In his place the Directors propose, with the approval of the shareholders, to elect the Right Hon. Sir Edward Thornton, G.C.B.

The auditors, Messrs. Pixley and Co., retire according to the articles, and offer themselves for re-election.

In conclusion the Directors congratulate the shareholders on the position and prospects of the Company.

NEW COMPANIES REGISTERED.

LEEDS AND LONDON ELECTRICAL ENGINEERING COMPANY (LIMITED).—Registered by Wilson, Bristows, and Carpmael, 1, Copthall-buildings, E.C., with a capital of £100,000 in £5 shares. Object, to form centres in any towns and districts in the United Kingdom or elsewhere, at which electrical energy may be generated and accumulated, and from which the same may be distributed. There shall not be less than three nor more than seven Directors; the first to be appointed by the subscribers to the memorandum of association. Qualification, £500. Remuneration, one-tenth of net profits after 7 per cent. dividend, with the proviso that the same shall not exceed £1,500 divisible.

ELECTRO-METALLURGICAL COMPANY (LIMITED).—Registered by T. H. Philpots, Rolls Chambers, 89, Chancery-lane, with a capital of £2,500 in £5 shares. Object, to acquire the business of the Electro-Metallurgical Company, now carried on at 23, Newhall-hill, Birmingham, and the Victoria Plating Company, carried on at 9 and 10, Sherbourne-road, Balsall-heath, Birmingham. The regulations of Table A mainly apply.

NEW COMPANIES REGISTERED DURING SEPTEMBER.—The following electrical and engineering companies were registered during the month of September:—

	Capital.
Combination Telephone and Electrical Engineering Company (£1 shares)	£20,000
Electrical Inventions (£1 shares)	35,000
Elmore's Austro-Hungarian Patent Copper Depositing Company (£2 shares)	200,000
Elmore's French Patent Copper Depositing Company (£2 shares).	200,000
Freedman Battery Company (£1 shares)	2,000
J. E. H. Gordon (£10 shares)	50,000
Railway Construction and Maintenance Company (£10 shares)	100,000

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).—The accounts of this Company, subject to audit, show a profit sufficient to enable the Directors to recommend a final dividend of 3s. per share, making, with previous distributions, a total dividend of 6 per cent. for the year ending June 30, 1890; and also admits of the payment of a bonus of 3s. per share, both free of income-tax, which, together, will amount to £39,000, being a distribution in the aggregate of 7½ per cent. for the past year, leaving a balance of £42,416. 18s. 1d., of which amount £40,000 has been placed to the Reserve Fund, increasing that fund to £352,626. 2s. 11d. and £2,416. 18s. 1d. carried forward. For the purpose of paying the above dividend and bonus on the 23rd inst., the register of transfers will be closed from the 14th to the 22nd inst., both days inclusive. The receipts of this Company for the week ended October 3 amounted to £5,323.

CUBA SUBMARINE TELEGRAPH COMPANY.—The estimated traffic receipts of this Company for the month of September were £3,000, as compared with £2,372 in the corresponding month of last year. The receipts for the month of June, estimated at £3,300, realised £3,324.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this Company for the month of September were £2,526, as compared with £2,139 in the corresponding period last year, an increase of £387.

EASTERN TELEGRAPH COMPANY, LIMITED.—This Company announce the payment by warrants on 1st November next of interest for the half-year ending 31st October on their 4 per cent. mortgage debenture stock. The transfer books will be closed from the 28th October to the 1st November, both days inclusive. The traffic receipts of the Company for the month of September, 1890, amounted to £55,346, as against £51,881 for the corresponding period of 1889, or an increase of £3,465.

EASTERN EXTENSION TELEGRAPH COMPANY.—The receipts of this Company for September amounted to £43,938, as against £40,418 in the corresponding period, showing an increase of £3,520.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this Company are as follows:—Receipts in September, 1890, £25,800; 1st January to 30th September, 1890, £206,800; corresponding months, 1889, £205,200; corresponding months, 1888, £202,600.

REUTER'S TELEGRAM COMPANY.—The Directors of this Company have declared an interim dividend at the rate of 5 per cent. per annum, free of income-tax, for the half-year ended June 30th last, payable on the 11th inst.

STOCK EXCHANGE.—Application has been made to the Committee to allow 4,000 additional shares of Bell's Asbestos Company (Limited) to be quoted in the official list.

TELEPHONE COMPANY OF AUSTRIA.—This Company has declared the usual half yearly dividend to the 30th ult. on the Preference shares at the rate of 6 per cent. per annum, payable, tax free, at an early date.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this Company for the month ending 30th September, 1890, amounted to £5,050.

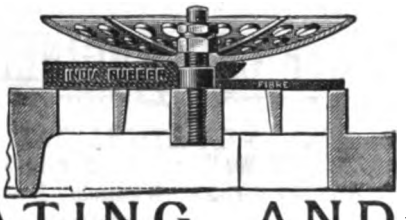
WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this Company for the half-month ended September 30th amounted to £2,405, as compared with £2,218 in the corresponding period, an increase of £187.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ending October 3, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,163.

WOODHOUSE AND RAWSON (LIMITED).—An extraordinary general meeting of the shareholders of this Company was held yesterday, at Worcester House, Walbrook, E.C., for the purpose of receiving the liquidators' statement of assets and liabilities of the Company and as to the position of the liquidation, and for the purpose of considering, and, if thought fit, sanctioning certain compromises or arrangements by the liquidators with (1) Woodhouse and Rawson United (Limited), (2) Albert Hoster, one of the liquidators, (3) Frederick Lawrence Rawson, one of the liquidators, and (4) the Schulke Gas Lamp Company (Limited), the particulars of which compromises or arrangements were laid before the meeting; and for the purpose of considering, and, if thought fit, sanctioning the compromise or arrangement by the liquidators with Woodhouse and Rawson United (Limited), on such terms as the liquidators shall consider desirable, of further questions pending between the liquidators and Woodhouse and Rawson United (Limited) with reference to the payment of the sum of £75,000, payable in certain events by the said Woodhouse and Rawson United (Limited), to this Company in the month of July, 1892; and for the purpose of considering, and if thought fit, sanctioning the immediate payment and distribution to and amongst the holders of the ordinary shares of the Company, of the amounts in cash and shares as provided by the arrangement made by the liquidators with the holders of the founders' shares, persuant to the extraordinary resolution passed at the general meeting of the Company held on June 23, 1890, and also for the purpose of reconsidering the question of the remuneration of the liquidators, and, if thought fit, amending the resolution of the extraordinary general meeting of the Company held on September 26, 1889, with reference thereto. Particulars of the meeting will be found in another column.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept. 1888.

"DEAR SIRS,—In reply to your letter of the 26th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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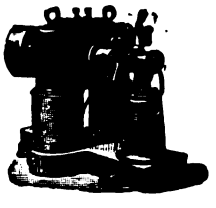
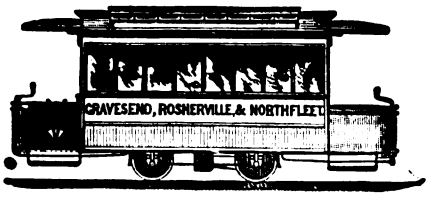
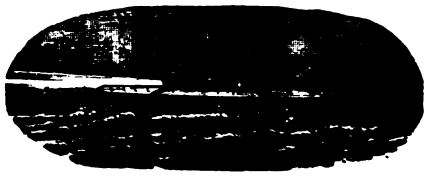
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 1.		Price Wednesday, Oct. 8.		Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 1.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
1,381,390	Stock	15/0	Anglo-American	51	52	50½	51½	5 11 8	Jan., Apr., July, Oct.	51	..
2,809,310	Stock	30/0	Do. Preferred	87½	88½	87	88	6 10 8	" "	88⅝	87
2,809,310	Stock	..	Do. Deferred	14¾	15⅛	14½	14⅝	..	.. ..	14⅝	14½
25,000	£100	4%	African Direct, 4 per Cent. Debentures	98	101	98	101	3 19 3	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine	11⅜	12⅛	11⅜	12⅛	5 6 1	Mar., June, Oct., Dec.	11⅛	11⅛
69,200	100	5%	Do. 5 per Cent. Bonds	100	102	100	102	4 18 0	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	..	..
$7,216,000	$100	..	Commercial Cables	102	104	102	104	..	..	103½	..
£16,000	£10	8/0	Cuba Submarine	11½	12	11½	12	7 1 8	February and August	..	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	2/4⅛	Direct Spanish (£4 paid)	4	4½	4	4½	5 6 8	March & September	..	..
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October	..	..
60,710	20	3/6	Direct United States	10⅜	10⅝	10⅜	10⅝	6 11 9	Jan., Apr., July, Oct.	10⅝	10⅞
400,000	10	5/6	Eastern	14	14½	14	14½	4 11 3	" "	14½	14⅛
70,000	10	6%	Do. 6 per Cent. Preference	15	15½	15	15½	3 17 5	" "	15½	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock	104	107	104	107	3 14 9	May and November	105⅛	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	108	..
250,000	10	2/6	Eastern Extension	14½	14⅝	14½	14⅝	4 17 5	Jan., Apr., July, Oct.	14⅝	14½
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Aust'n. Gov. Sub.) Debs. 1900	101	104	102	105	4 15 3	January and July ..	102½	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900	102	105	101	104	4 16 2	.. ..	102⅝	..
180,227	10	4/3	Globe Telegraph and Trust	8⅞	9⅛	8⅞	9⅛	5 9 7	Jan., Apr., July, Oct.	9⅛	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14⅞	15⅛	14⅞	15	4 0 0	" "	14⅞	14⅞
150,000	10	5/0	Great Northern	15⅞	16⅛	15⅞	16⅛	4 12 4	Jan., April, and July	16⅛	15⅞
15,000	100	5%	Do. 5 per Cent Debentures, 1881	100	103	101	104	4 16 2	January and July ..	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104	107	104	107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European	36	38	36	38	6 11 7	April and October ..	36⅛	36⅛
33,348	10	4/0	London Platino-Brazilian	6⅛	7⅛	6⅛	7⅛	5 6 8	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	6/0	Reuter's	9⅛	8⅝	8⅛	8⅝	5 14 4	April and October	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust	113	117	113	117	5 2 7	" "	..	..
15,609	£10	6/6	West African	9	10	8	9	5 11 1	.. ..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	99	102	98	101	4 19 0	March & September	100⅜	99
30,000	10	3/0	West Coast of America	4⅛	5	4⅛	5	10 0 0	January and July ..	..	..
150,000	100	8%	Do. Debentures 8%	102	107	102	107	7 9 7	June and December	103⅛	..
88,321	10	Nil.	West India and Panama	3	3⅛	2⅝	3⅛	.. ..	..	3⅛	2⅛
34,563	10	6/0	Do. 1st Preference 6%	11⅛	12	11⅛	12	5 0 0	April and October	11⅛	11⅛
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	14	15	14	15	4 0 0	.. ..	..	..
64,572	15	6/0	Western and Brazilian	11⅛	11⅜	11⅛	11⅜	5 2 3	May and November	11⅜	11⅛
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅞	7⅛	6⅞	7⅛	..	..	7	6⅞
26,986	7½	4/6	Do. 5 per Cent. Deferred	4⅞	5⅛	4⅞	5⅛	..	..	4⅞	4⅞
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103	106	103	106	5 13 2	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	103	106	103	106	5 13 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	122	127	122	127	5 10 3	May and November	..	..
£175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	103	99	103	5 16 6	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5⅝	Consolidated Telephone Const. and Maintenance	⅛	¼	⅛	¼	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	⅛	¼	⅛	¼	4 8 3	Yearly	..	..
436,700	5	3/0	National	4⅛	4⅜	4⅛	4⅜	6 9 9	June and December	4⅛	4⅛
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12¼	12⅝	12¼	12⅝	..	June and December	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10	10⅜	10	10⅜	5 14 3	" "	12⅛	..
219,750	1	⅛%	South of England, Ordinary	⅛		⅛		..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd)	2½	3	2½	3	..	..	..	..
55,000	5	1/0	United River Plate	3½	4	3½	4	..	January and July	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅜	2⅝	2⅜	2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£8 paid)	4	4½	5½	6	..	..	5⅜	3⅞
42,853	5	..	Westminster Electric Supply	1	1⅛	1⅛	1⅜	..	..	1⅛	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1⅛	2	1⅛	1⅜	..	..	1⅜	1⅜
63,416	2	0/10	Do. Preference	1⅜	2	1⅛	2	..	..	1⅜	1⅛
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5½	5⅝	5½	5⅝	..	..	..	..
353,478	5	..	Edison and Swan United	..		..		..	..	..	..
409,000	10	..	Electric Construction	7⅜	8½	7⅜	8½	..	..	7⅜	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5	5½	5	5½	..	..	5⅝	5½
20,000	5	..	Fowler-Waring Cables	2½	3	2½	3⅛	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	18	19	18⅜	19½	5 2 7	February & August	19	18⅜
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	100	102	100	102	4 8 3	..	101⅜	..
78,949	5	6%	Swan United (£3. 10s. paid)	5½	5⅝	5½	5⅝	3 12 11	..	5⅝	5⅜
37,350	12	12/0	Telegraph Construction and Maintenance	43	45	43	45	5 6 8	March and July	44½	43½
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100	102	100	102	4 18 0	..	..	..







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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

At the Corporation enquiry into the water supply of the Metropolis last Monday it transpired that the number of Acts of Parliament passed, transferring the water supply to local authorities, now numbered over seventy. As illustrating the extent to which these bodies have applied themselves of late years to the superseding of private Corporations, this fact is worth noting.

The laying of mains in the streets of London is a new art. The more serious excavations of the Gas and Water Companies were far more simple to arrange, as there was nobody there before them. For more than one reason the conductors are being put, when possible, under the foot-pavement; but, besides the numerous occasions on which he has to cross the streets, the crowns of the cellars or the structure of the houses frequently compel the engineer to turn into the road, and to explore the labyrinth of pipes below its surface. Being obliged to go to a considerable depth, he comes against the water and other pipes, and rarely does he care to use his powers to divert them. But according to an abstract in the last volume of the *Proceedings* of the Institution of Civil Engineers, it was found necessary to alter the position of the main conduit of the water supply of the town of Hague, and the superintendent of the waterworks resolved to try the bold plan of slewing a length of 273 yards, weighing 65 tons, sideways bodily, without stopping the supply. "No leaks of importance occurred in the lead joints," which speaks highly for the quality of the original work, but will hardly encourage electrical contractors to repeat the operation when they find the proposed route of their conduits impeded by a water-main.

In the September number of the *Philosophical Magazine* will be found a remarkable Paper by Prof. Langley, entitled "The Cheapest Form of Light." The important question whether it is possible to produce illumination with less waste of energy in mere heat than is now the case by electrical or any other means, is discussed with especial reference to phenomena of phosphorescence; since it is by the study of the latter that economy in future lighting will most likely be brought about. The light produced by the glow-worm does not appear to be indissolubly connected with the life of the organism. It persists after death, is stimulated by oxygen, and is extinguished in a vacuum or in an atmosphere such as carbonic acid gas. It is apparently the result of slow combustion; and there is nothing to forbid the hope that it may be ultimately possible to reproduce this kind of light on a large scale by purely material means. The result of photometric measurements is to show that the radiation of the glow-worm is much more confined to the luminous part of the spectrum than is the case with solar radiation or any other known source of light; and hence it has always been assumed that much less heat is needed for its production than in any other case. The truth of this assumption has never been established by actual thermal measurements, owing to the extreme delicacy of the apparatus required. Prof. Langley has, however, with the aid of the bolometer, been enabled to establish the fact beyond a doubt, and has shown that the insect's light is accompanied by less than one four-hundredth part of the heat given out by an equal amount of gas light.

Some idea of the smallness of the quantities measured is conveyed by the statement that the heat given off from the glow-worm per second, exclusive of mere animal heat, was less than one millionth part of a gramme degree, and the portion of this falling on the bolometer in one second was not enough to raise an ordinary mercurial thermometer one millionth part of a degree centigrade. The most important measurements made are shown graphically in certain curves, which we are able to reproduce in this issue; and practically the investigation shows that the light of the fire-fly is produced at the expense of one four-hundredth part of the energy of an equal amount of gas light, and at the cost of a small fraction of the energy of an electric light of similar power.

It is somewhat surprising to find that the Edison General Electric Company of the United States are putting forward as a new invention a mode of winding drum armatures under the name of the Edison-Eickmeyer system. The paragraph announcing it in the American papers says that all the tramway companies are using Siemens armatures with the old winding, in which the wires cross at the ends and become heaped up in a cone. The "half round and under" method was well known in this country before the Siemens patent ran out, and a system ascribed to Crompton and Swinburne is clearly shown in the second edition of Prof. S. P. Thompson's "Dynamo-Electric Machinery." There are several different ways of preventing the heaping-up, which is never to be found in a good modern drum armature; and there are several arrangements for avoiding the crossing which constantly led to short-circuits, and which was always troublesome to repair.

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THE somewhat lengthy Paper which has been presented to the Royal Scottish Society of Arts, "On the Telpher and Electric Railways of the Edinburgh Exhibition," is not calculated to assist the development of electric traction to the extent that its authors desire. Not long ago we were informed that the series system was far and away the best and most economical. The Northfleet line was to be the first specimen, and the tramway companies would find that it was what they had all been waiting for. But in this Paper the Northfleet line is dismissed in six and a-half lines, without even a word to say that it is working well. A long account is given of the Telpher system at Eastpool, Cornwall, and of the ingenious devices which are necessary in the construction of both line and locomotive. The originator, unfortunately, did not live to see it beyond the toy stage, and it is difficult to say what advances have since been made. The centrifugal governor of Prof. FLEEMING JENKIN, which cuts off the current when the train goes too fast, is still retained; but why it should survive in this application, when the knowledge of governing motors has advanced so much, we are not told.

THE great feature of the flexible line is still prominent, but it appears that a good many special arrangements are needed to make it efficient. The end over which the loaded train runs is strained with a weight of six tons, and the side which carries the light one is kept taut by four tons hung on to the end. The sags per span are four feet and five feet on the light and loaded lines respectively; and "the locomotives are so spaced that one locomotive is always descending a sag, whilst the other locomotive is ascending a sag." The advantages of this system, hampered as it is by so many subsidiary details, are not so apparent as one might wish; but we hope that in practice it will work well, and permit of some simplification.

WITH no less than three distinct systems of traction in hand, the Electrical Engineering Corporation appear to be very sanguine of the rapid advance of that branch of electrical engineering in this country. But it does not seem that their arguments will help the cause when they inform us that "the large mileage thus being worked in America enables us to form a judgment beyond question as to the cost of operating electrical tramways from fixed conductors either overhead or underground, and we may take the figure of 3d. per car mile as the total amount for traction." Now, we do not doubt that this 3d. per mile will be shown before long on the balance-sheet of some carefully planned and well engineered undertaking; but to take American prices as an argument for this purpose is as rash as to propose to start a Shoe-blacking Company, on the strength of the fact that half-a-dollar is commonly charged in New York for this service.

THE authors of this paper do not hesitate to describe a fourth system in addition to those they have taken under their protection; but in stating that "the method with conductors suspended overhead is the method adopted by an overwhelming large percentage of the electrical tramways in existence," they will not convince our countrymen that such conductors are not objectionable, even when "the City of Boston, supposed to be one of the finest, architecturally, in the United States, is being fitted up with overhead conductors." As a matter of fact objections have been raised there; but why use arguments based on practice in America, when in that country railways run through and across the streets of crowded cities, and neither bells nor cow-catchers prevent numberless accidents? It is certain that most of the present tramway companies and many investors who will some day equip new lines, are only waiting to see electric traction in a satisfactory form and at a fair cost. If the Electric Engineering Company would work towards this end, instead of expending its energies in providing attractions for an unnecessary and unappreciated Exhibition, the result would be more speedily attained.

THE number of different sets of rules for wiring is almost as great as the number of different sources from which they have emanated. We have in this country the fire insurance offices, the Institution of Electrical Engineers, the supply companies, the Board of Trade, and the inventor. Those of the first are too vague; the second too academical; the third relate to the tests that will be applied, rather than the manner in which the work is to be done; the fourth is not much concerned with anything short of an earth on the consumer's side of the terminals; the last merely describes his own system. The municipal authorities of Hanover have issued a very elaborate set of rules in connection with the extensive supply system with which they are providing that City. We have a similar case, on a much smaller scale, at Bradford, whose Corporation have issued a brief set of regulations. The abstract, which will be found in another column, of the Hanover rules, exhibits a paternal interest on the part of the authorities, and they will probably fail to meet Mr. Wilson Hartnell's approval in the matter of current density; but several of the points are worth the consideration of those who desire one standard set of rules.

WE learn that the contract for the erection of the municipal central lighting station at Copenhagen, for which several English firms were tendering, has been obtained by Siemens and Halske, of Berlin. Prof. Jurgensen is connected with the undertaking.

Paisley.—The Town Council have agreed to apply for an electric lighting Provisional Order.

Telegrams for Guatemala.—We are informed that telegraphic communication with Guatemala has been restored.

Newcastle.—At the last meeting of the Town Council it was resolved to introduce the electric light into the Public Free Library at a cost of £600.

Monmouth.—At the last meeting of the Town Council it was decided, after hearing the report of a deputation who had visited Fareham, to light the borough with electricity.

University College of North Wales.—The bequest to the University College of North Wales, under the will of Dr. Evan Thomas, of Manchester, is officially announced to be £39,500.

The Spanish-African Cables.—*The Gaceta Oficial* will publish this week the new conditions in connection with the tenders for the laying of cables between Spain and her African possessions.

Birmingham.—The driver of one of the accumulator cars on the Bristol-road line last week, lost control of it while descending an incline, but the car was ultimately pulled up before any mishap occurred.

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The Channel Telephone Cable.—We understand that Messrs. Siemens Bros. and Co. have secured the contract for manufacturing the 4-cored cable to be used for telephoning across the Channel.

Lyric Theatre.—We understand that Mr. Horace Ledger has contracted with the St. James and Pall Mall Electric Light Company (Limited) for the supply of all the current required for lighting the Lyric Theatre.

Lewes.—At the adjourned public meeting of the Lewes ratepayers, held to consider the lighting question, it was resolved to ask the Corporation to make inquiries with regard to electric lighting and to take a poll of the town.

Nelson.—The Local Board have decided to lay down an electric light installation for 600 lights. Already shopkeepers have applied for 200 lights, and no difficulty is expected in obtaining applications for the remainder.

Copenhagen.—A new College of Engineering was opened at Copenhagen on 1st September with much ceremony. The old College, erected some sixty years ago, had for its first Director Hans Christian Orsted. The Director of the new College is Prof. Julius Thomsen.

Newington Vestry.—At the last meeting of this Vestry a letter was received from the London Electric Supply Corporation, stating their intention to commence the laying of electrical mains in Blackman-street, Newington-causeway, Newington-butts, and the Walworth-road.

Board of Trade Rules.—We are indebted to the Electric Department of the Board of Trade for a copy of the Regulations for supply under the Order of the Metropolitan Electric Supply Company (West London). These rules are verbally identical with those made under the Notting-hill Order, which we published on August 29th (p. 466).

Fiume.—The Town Council has granted a concession to the international Elektricitäts Gesellschaft of Vienna, to erect a central light and power station. In addition to the lighting of the harbour and railway station, electric power will be used for the working of elevators, and perhaps also for a railway one mile long, uniting the two ends of the town.

Action against a Labour Union.—Some employers in the Connellsville (U.S.A.) coke region have brought an action against their ex-employés and the officials of the local branch of the Knights of Labour for an alleged breach of agreement. Damages to the amount of £20,000 are demanded. It will be interesting to see what the Law Courts will make of this matter.

New Books.—Amongst the new books announced by Messrs. Crosby Lockwood and Sons are "The Mechanical Engineers' Office Book for Machine and Boiler Construction," by Nelson Foley; "The Analysis and Valuation of Fuel," by H. J. Phillips; "Asbestos, its Properties, Occurrence, and Uses," by R. H. Jones; "Electric Light: its Production and Use," by J. W. Urquhart. Fourth edition. Revised and extended.

SS. "Silvertown."—Some members of the technical Press and a small party of friends were entertained at luncheon on board the India-Rubber, Gutta-Percha and Telegraph Works Company's cable ship "Silvertown" on Friday last. The ship lay off Greenhithe, and was about to start for South America to lay the Lima-Valparaiso cable of the Central and South American Telegraph Company. The "Silvertown" is expected to be away on this expedition for about six months.

The Electric Light in the Meuse Forts.—A committee, appointed by the Belgian Ministry of War, has been making trials at the works of the "Société de la Meuse," with the new armoured electric light towers, designed for the forts along the Meuse. These are steel turrets, intended as a protection to the projectors and the men in charge of them. The light is furnished by a very powerful self-focussing arc lamp, the current for which is obtained from a dynamo driven by a gas engine.

Cable Extensions in the West Indies.—The Compagnie Française des Télégraphes Sous-Marins are pushing forward the completion of the network of cables connecting French Guiana with Brazil on the one hand, and with the West Indies and North America on the other. The Martinique-Paramaribo section, 660 miles in length, is about to be shipped, and will be laid before the end of the year. This cable has been manufactured by the Société Générale des Téléphones at their Bezons works.

Institution of Mechanical Engineers.—The ordinary general meeting of this Institution will be held on Wednesday evening, 29th October, and Thursday evening, 30th October, at 25, Great George-street, Westminster. The following Papers will be read and discussed, as far as time permits:—"On Tube-Frame Goods-Waggons of Light Weight and Large Capacity, and their Effect upon the Working Expenses of Railways," by Mr. M. R. Jefferds; "On Milling Cutters," by Mr. George Addy; "On the Mechanical Treatment of Moulding Sand," by Mr. Walter Bagshaw.

The London Electric Supply Corporation Mains.—Major C. B. Waller, the manager and secretary of the London Electric Supply Corporation, was summoned by the Vestry of St. George the Martyr, Southwark, for cutting away and taking out part of a sewer in Union-street, Borough, for the purpose of laying electric lighting mains without first having obtained the permission of the Vestry. For the defendants it was urged that the Vestry had no power to interfere; and in the end the summons was adjourned, to give both parties an opportunity of referring the matter to the Board of Trade.

Edinburgh Exhibition.—The Royal Scottish Society of Arts held a Special Session at the Exhibition on October 13th, under the presidency of Lord Kingsburgh. Five Papers were read, three of which were electrical, viz., "On the Telegraphic Exhibits," by Prof. Grant-Ogilvie; "Telepherage and Electric Railways," by Mr. E. Manville; and "Electrical Navigation," by Mr. A. R. Bennett. There was a large attendance of members. The members afterwards took trips on the telpherway and electric tramway and in the electric launches; and a special vote of thanks was accorded to Mr. Bennett, to whose invitation the meeting had been due.

Personal.—Mr. Oddie, of Ballarat (Australia), who was recently in this country, before leaving England commissioned Mr. Goodwyn Lewis to paint a portrait of Mr. Thomas Parker, with whom he had become acquainted. This picture is intended to be fixed in the Ballarat Art Gallery as a present from Mr. Oddie to the town of Ballarat. It will be exhibited in Wolverhampton shortly.——Mr. Oswald Haes, who is an old student of the Finsbury Technical College, and has been on the engineering staff of the Brush Electrical Engineering Company and its predecessor for three years, has been appointed to the management of the engineering department of the Company's branch in Australia, and is about to proceed to Sydney, New South Wales, to take up his position.

Alloys for Fuses.—The following proportions for fusible alloys may be of interest—they are due to Weisbach, and have been used in actual practice:—

Lead.	Tin.	Bismuth.	Melting points in degrees Centigrade.
1	1	4	93·8
5	3	8	94·4
2	3	5	94·4
1	4	5	118·8
1	4	1	125·0
1	1	1	241·1
1	2	1	167·7
1	3	1	167·7
1	3	1	200·0

Leamington.—At a meeting of the Town Council on Monday the report of the Watch and Lighting Committee was read, showing that tests had been made from time to time of the electric light; and of the lamps tested the registered illuminating power ranged from 10·2 candles to 14·5, the illuminating power specified in the contract being 16 candles. A discussion ensued, in the course of which it was stated that the light was most unsatisfactory. Mr. C. Davies proposed that the Town Clerk should be requested to consider whether the Electric

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Light and Power Company could be required to recoup the Corporation in respect of the past payments to the Company having been made on the basis of the supply of a 16-candle power light, which had not been supplied. The motion was adopted.

Ninove (Belgium).—The township of Ninove has entered into a thirty years' contract with a Brussels electric lighting company, and its streets were lit up for the first time by electricity on October 1st. The plant consists of two 16·8 kilowatt Siemens dynamos and a battery of Tudor accumulators. The wires, which are of bronze, are run overhead, and the radius of supply is more than 800 metres on either side of the central station. The public lighting is carried out with 120 25 candle-power lamps. A portion of the street lamps are automatically switched off at midnight, and during the winter automatically switched on again at six in the morning to light the streets for the factory hands. The charge for private consumers is nine centimes per 100 watts-hours (9d. per Board of Trade unit). The price of gas at Ninove is at present 18 centimes per cubic metre (4s. 6d. per thousand cubic feet).

Radial Axles for Tram-Cars.—The additional power required to propel a tram-car round a curve was not appreciated until electric traction became common. It has been found on the Boston lines that the current will go up five or ten amperes when the car rounds a curve. To avoid this loss, cars have been built with three axles and six wheels, two of the axles carrying motors and four of the wheels being drivers. The driving axles are on bogies turning on pivots; the third axle is on a bogie which can slide sideways under the car. The same principle has been tried on the Indian railways, but without very good results. The dimensions of the car are as follows:—Length over all, 36ft. 4in.; length of body, 28ft.; wheel base, 15ft.; seating capacity, 42 passengers; carrying capacity, including standing room, 150. These cars have been running satisfactorily for several months.

Localisation of a Fault in an Electric Light Circuit.—In a recent number of *La Lumière Electrique* M. Henri Wilbrant states that he was lately able to localise a fault in an underground electric light circuit to within five metres (the total length of the circuit being 900 metres) by the following method. He looped together the lead and return at both ends, and connected a battery, one pole of which was to earth, to one junction. In each lead an ammeter was inserted. If C_1 = current flowing to the earth along one branch of the circuit, and C_2 = current flowing to the earth along the other branch x; and if L = the total length of the looped cable, we have $\frac{C_1}{C_2} = \frac{x}{L-x}$ or $x = \frac{C_1 L}{C_1 + C_2}$. The two cables must, of course, be identical and of the same resistance per unit length throughout, in order that their lengths may be taken as proportional to their resistances.

Obituary.—We regret to have to announce the death of Dr. Emil Stöhrer, whose name has been connected with several most important improvements in telegraphy. Dr. Stöhrer died at Dresden, after a prolonged illness, on the 25th of August. Born in 1812, he was the son of a surgeon in Delitzsch, and in 1842 set up a small mechanical workshop in Leipsic. In 1844 he first tried to use his improved magneto-electric machine for telegraphic purposes, and two years later he succeeded in getting a Government order for two of these machines for use with the double-needle instrument on the Bremen-Bremerhaven line, and in 1847 two of these instruments were installed in the Imperial telegraph office in Vienna. His magneto-electric dial telegraphs were adopted in 1846 for Bremen-Bremerhafen, in 1847 for the railway service between Leipsic and Altenburg, and in 1850 on the railways of the Bavarian Government. During his last years Dr. Stöhrer devoted himself chiefly to medical electricity.

Electric Traction in Canada.—From the number of applications for charters in Ontario and Canada generally for power to operate railroads in which electricity is mentioned as the motive power, it is very evident, says the *Electrical, Mechanical, and Milling News* of Toronto, that there is to be a boom in the electric motor business in this country. Considerable interest will attach to the starting of the electric road in North Toronto, which is expected to take place in a few weeks. The conditions under which it will operate will be about as difficult as are to be found anywhere—pretty stiff gradients, a road-bed, while good enough for single horse cars, scarcely of sufficient solidity for heavy traffic and considerable loads on special occasions. Negotiations are also all but completed for a complete system of electric street railway in the City of Ottawa, where it is expected the availability of water-power will make it a very satisfactory investment. Round Toronto also there are several roads talked of, such as between Mimico and the terminus in Parkdale, and West Toronto Junction to the City; so that, on the whole, considerable activity may be looked forward to in the near future in this field.

Electric Motors for Street Railway Purposes.—In a Paper read before the New York Street Railway Association at Rochester, the President of the Albany Street Railway was very emphatic in his remarks on the electric motor:—"Over four months' experience has taught us that the electric motor is efficient and reliable, though we have yet to learn, by experience, that it will ascend an 8 per cent. grade at the rate of five miles per hour in winter, as it has during the summer. How the motor is to be arranged with reference to the car body so as to admit of easy access to it for examination and repair must be left to mechanical and electrical engineers. That we will continue to drag them in the dust and mud very long I cannot believe. I think the opinion of all who are unprejudiced is that the overhead single trolley under contact systems are the most reliable and efficient. The question as to whether the electric motor is as economical as the horse car cannot yet be answered, and need not be answered. Just as certainly as the horse car supplanted the omnibus, the electric motor will supplant the horse car. The horse car, however economical, must go; and the electric motor, no matter how expensive, must come."

City and Guilds of London Central Institution.—More than 100 candidates entered at the end of September for the Matriculation examination at the City and Guilds Central Institution, and of these 60 passed, and 16 did sufficiently well to be allowed to enter the College as unmatriculated students. In addition to the regular students in their second and third years, and the 76 above referred to, who are admitted to attend courses in *all* the four departments of Mathematics and Mechanics, Engineering, Physics, and Chemistry, some 20 special students have entered for portions of the advanced courses in one or more of these departments. On the result of the entrance examination the Clothworkers' scholarship of £60 a year, with free education, tenable for two years and renewable for a third, was gained by C. E. Stamp from St. Paul's School, and the three Institutes' scholarships, each of sufficient value to cover the student's fees for three years at the Central Institution, were gained by G. H. Baillie from Winchester House School, C. V. Drysdale from the Finsbury Technical College, and A. A. Sonneborn from Tottenham College. At the end of last session the John Samuel scholarship, granted to a meritorious student of the Central Institution at the close of his second year's course, and consisting of £30 and free education for the third year, was awarded to C. W. Clinton; the Siemens medal, given to the student of greatest merit in the department of Electrical Engineering, was taken by R. Wightman.

The New Standard Edison Electrolytic Meter.—At the Minneapolis meeting of the Edison Illuminating Companies, Mr. A. E. Kennelly stated that since the last meeting of the Association the new and improved pattern of the Edison meter had been decided upon, and had already been introduced into two stations (Brooklyn and Winnipeg); and the reports upon its behaviour in each case were excellent. There are four standard sizes. They are numbered 1, 2, 4, and 8, respectively; designed to supply 40, 80, 160, and 320 lamps. In all sizes, the bottles, plates, and spools are alike, making the resistance of the bottle circuit the same in every meter. In the smallest meter each milligram of weight transferred represents one ampere hour of supply, and the transfer is 10 milligrammes per hour on full load. Similarly every meter transfers 10 milligrammes per hour at full load, so that each milligramme of transfer in a No. 8 meter represents eight ampere hours, and in a No. 4 meter

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four ampere hours, the number of the meter being the index of the supply in each case. A cause of discrepancy in the electrolytic meter has always existed in a slight gain of the plates in weight independently of the current's action and due to their oxidation superficially. With the old meters it increased with the size of the meter, since a larger plate offered a larger surface of oxidization. In the new pattern it is a fixed amount in all sizes, and owing to the small area of plate is in any case very small. Another improvement is in the plates. These are castings of pure zinc alloyed with 2 per cent. by weight of pure mercury. The only other noteworthy change has been in the solution, which is about twice as dense as in the old bottles.

The Wheless System of Electric Traction.—The overhead system of electric traction, judging by recent statements in the American technical journals, is not altogether admired, even in the United States; and electric traction engineers in that country are beginning to encounter, though, of course, in a modified form, that strenuous opposition to trolley-wires, &c., which makes such a system out of the question for the majority of English towns. Thus, at Washington, D.C., by a recent enactment of the local legislature, it has been decided that there shall be no resort to the overhead system. If electricity is to be employed, it must be in some other way than that; and the legislation has been made absolutely prohibitive. This prohibition is the more noteworthy since, in the Eckington and Soldiers' Home line, Washington possesses an example of the overhead system, which is as close an approximation to the ornamental as could be expected. One result of this enactment has been a trial of the Wheless conduit system, which was briefly described in *The Electrician* of November 29, 1889. Mr. Wheless' system has, however, been completely transformed since that date. As then described it was a closed-conduit series system; as now described in *The Electrical Engineer* of New York, it is a combined open and closed conduit system. A well-insulated main cable is buried by the side of the track, and the current is automatically switched into successive sections of a bare conductor placed in the conduit. This switching is effected as the car moves along by means of electro-magnets energised by a couple of storage cells on the car.

The Elmira (N.Y.) Electric Railway.—On July 30th the Elmira and Horseheads Railway Company, says the *Electrical Engineer* of New York, placed a contract with the Edison Company for the equipment of about 1½ miles of track, six motor cars, and a full station equipment. At the same time, a contract was placed with the John Stephenson Car Company for six new cars. The contracts were made, in both cases, with the strong guarantee that the roads should go into operation on September 1st. On August 15th the Stephenson Company announced that its cars were ready for equipment, and at about the same time the motors were shipped from the Schenectady Works. The strike on the New York Central Railway at this time bid fair to cause serious delay, as the cars were to be equipped in New York. However, the motors were sent to the cars by a roundabout route, and on August 20th the completed cars began to go out from the Stephenson factory at the rate of two per day. At 12 a.m. on August 23rd the street construction work commenced. Provision for the dynamos and appliances had been made by engaging a part of the Westinghouse station. On August 31st notice was sent to the railway company that the road would begin operation on the following morning, and at 6 a.m. on September 1st the road carried its first passengers. For the first few days the strains on the new machinery were excessive, the cars frequently having to carry two loaded trailers, and to remain in service from early morning until late at night. The number of passengers carried by these electric cars, with their complement of trail cars, in a day, was over 25,000.

Institution of Civil Engineers.—We have received from the Secretary of this Institution a copy of the current list of subjects upon which, among others, original communications are invited. The following are the subjects likely to be of interest to our readers:—The lighting of railway carriages by oil, gas and electricity compared; electrical traction for roads and railways; the design and arrangement of electric supply stations, and of electric distributing apparatus, for domestic, trade and general service in towns, particularly as to economy and safety; the comparative advantages of gas and electricity for lighting purposes; the application of electricity to bleaching; recent researches into the molecular properties of steel; the production of aluminium and its alloys, and their use for engineering purposes; electric mining machinery for pumping, hauling, and coal cutting in mines and collieries; the application of electricity to smelting and metallurgical operations; the electro-deposition of copper; the laying out of engineering workshops; the comparative merits of triple and quadruple expansion engines; friction at different velocities, and the comparative value of different lubricants; the utilisation and distribution of water power; windmills for raising water for general power purposes; liquid fuel motors, and their applications; the cost of the production and distribution of electrical energy; the distribution and application of electric power in towns; electrical measuring instruments, such as ammeters, voltmeters, power-meters, and supply-meters. This list is to be taken merely as suggestive, and not in any sense as exhaustive. For approved Papers the Council of the Institution has the power to award premiums, arising out of special funds bequeathed for the purpose, the particulars of the more important of which are as follows:—The Telford fund, this bequest produces £260 annually; the Miller fund, bequeathed for the purpose of forming a fund for providing premiums or prizes for the students of the Institution, this fund realises £150 per annum.

Engineering Ignorance.—In a recent article in the *American Machinist* Mr. W. K. Stevens discourses on the ignorance of engineers. In the acquirement of learning, he remarks, one of the first and most important steps is to discover how vastly ignorant we are. In engineering the world is now taking that step. In quite recent years we were contented with certain engineering rules and formulæ, if they were laid down by high authorities. Now, however, we are beginning to doubt the accuracy of the old authorities, and our confidence is extremely limited in the newer ones. Concerning iron and steel, how little is really known! Why should cast iron vary all the way from 12,000lb. to 45,000lb. tensile strength per square inch? In wrought iron and steel constructions, how shall we determine the best factor of safety? Who knows whether high carbon or low carbon steel is best adapted to resist repeated strains without crystallisation? Is there really any such thing as crystallisation of iron or steel? In the steam engine, is a steam jacket of any value? What is the amount of cylinder condensation with different types of engine, and with different points of cut-off? What is the most economical ratio of expansion for different classes of engines? If large engines have developed a horse-power with 13lb. of steam per hour, why is it necessary to use from two to four times that amount in small engines? In the use of bituminous coal, who knows how to obtain the maximum economy from different qualities? To remove ignorance and contribute to the advancement of real knowledge, we require careful scientific experiments and prompt publication of results. But there is already too much publication of crude observations. It were better if publication could be deferred until at least a year after making the observations. In fact, the increasing bulk of engineering publications is becoming a burden rather than a benefit. Each of the technical societies publishes a yearly volume, which tends to grow larger; and the number of such societies is steadily increasing. The scientific colleges publish monthly or quarterly magazines, and the technical and trade journals and the book-makers are doing their share to swell the bulk of matter which engineers are expected to read. But, out of all this vast mass, how little is there which really is a contribution to knowledge! Even in the "Transactions" of our technical societies, how few papers appear which have any permanent value! The great reason why the engineering profession is still so ignorant of facts and data in its own science is, that these facts and data are not easily obtainable in a shape which renders them valuable for comparison and permanent record. The immediate need of the profession in this matter is not more schools, more books, more society papers, but more experiment.

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MAGNETISM IN IRON AND OTHER METALS.*—XXXIII.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 636.*)

§ 120. **Effects of Stress: Introductory.**—No part of our subject is more interesting than that which deals with the effects of mechanical stress in altering the susceptibility, the retentiveness, and other qualities of the three magnetic metals. The matter is not, at least as yet, one of practical moment, for it has at present no direct bearing on any of the applications of magnetism; but its importance on the theoretical side is not easily overrated. The effects of stress form a fascinating subject of inquiry to the physical student, and are likely to play a considerable part in revealing the molecular structure which makes magnetisation possible. The subject is a large one, and the results that have been already obtained are too intricate to permit more than a very general account of them to be given here. It will be most convenient to state the salient facts, without much regard to the historical order of their discovery. The first inquirer in this field appears to have been Matteucci,† who noticed an increase of magnetism in a magnetised iron bar when the bar was pulled lengthwise. Villari ‡ made the important discovery that the character of this effect was liable to be reversed if the bar was sufficiently strongly magnetised: let the iron bar be weakly magnetised, and the effect of pull is to increase the magnetism; but let the bar be strongly magnetised, and the effect of pull is to reduce the magnetism. This "Villari reversal" (as it is now called) of the magnetic effects of stress in iron was rediscovered by Sir W. Thomson in the course of an inquiry which may be said to have laid the foundation of exact knowledge in this subject.‖ Thomson studied the effect of longitudinal stress by loading and unloading iron wire and steel wire in magnetic fields of various strengths; he extended the same method of investigation to nickel and cobalt. He found by experiment with a steel gun-barrel under hydraulic pressure that the effects of transverse stress were opposite in kind to those of longitudinal stress. Comparing the results of longitudinal and transverse pull, he pointed out that the effect of a simple pulling or pushing stress was to develop a difference of magnetic susceptibility in directions lying along and across the line of pull or push; and he applied this consideration to the case of torsional strain, deducing results which were verified by experiment, and discussing earlier experiments by Wiedemann, who, it may be added, has made the relations of torsion and magnetisation the subject of much detailed study.* The work of Thomson has been followed up and extended by others, particularly in the direction of investigating the forms which the magnetisation curve (the curve of I and H) assumes when the piece under test is subjected to various kinds and degrees of stress; and also of investigating, by continuous magnetometric observations, the manner in which a loaded piece gradually acquires or loses magnetism when the loads are varied, a constant magnetising force being kept in action. The effects of hysteresis, which present themselves at every turn in experiments on this subject, do much to complicate the results: and it is only by following both methods of inquiry—that is to say, by examining the consequences of changing the magnetic force while the state of stress is kept constant, and also those of changing the stress while the magnetic force is kept constant—that we can obtain a tolerably clear connected view of the phenomena.

§ 121. **Effects of Longitudinal Pull on the Susceptibility and Retentiveness of Nickel.**—It is most convenient to begin with nickel for the two reasons that the effects of stress are —for the most part—much greater in it than in the other metals, and are also simpler in one very material respect. There is nothing in nickel that corresponds to the Villari reversal in iron. If we apply pull to a magnetised rod or wire of nickel, we find—as Thomson first showed†—that pull diminishes the magnetism, and relaxation of pull increases the magnetism; and this effect is still observed, however strongly the piece be magnetised.

If we magnetise nickel while it is kept in a state of longitudinal tension by means of a constant load, we find an enormous reduction in its susceptibility. This is well shown by the curves of Fig. 95, which show the magnetisation of a long piece of annealed nickel wire under various amounts of longitudinal pull.‡ The wire was 0·068cm. in diameter, and 374 diameter long; its section was 0·363 sq. mm., so that each kilogramme of load produced a stress of 2·75 kilogrammes per sq. mm. The curves drawn in full lines show the relation of I to H when there was no load, and also when the load was

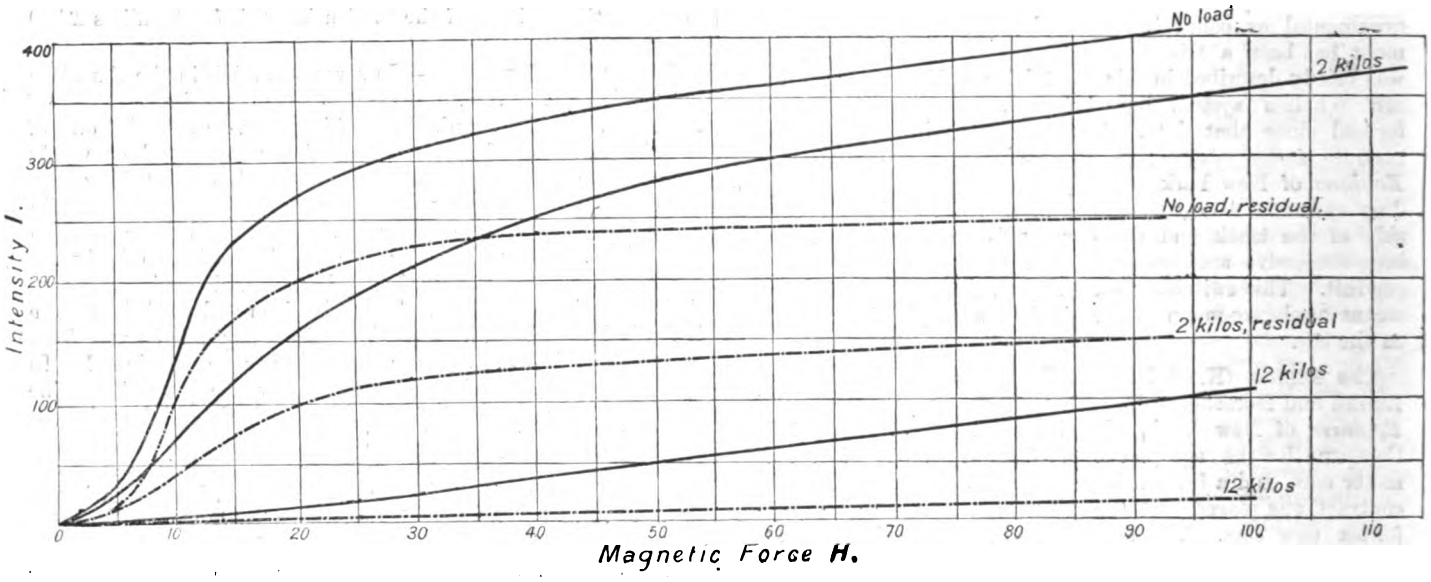

FIG. 95.—Magnetisation of annealed Nickel Wire under various amounts of longitudinal pull.

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† *Comptes Rendus*, 1847; *Ann. de Chimie et de Physique*, 1858.

‡ *Pogg. Ann.*, 1868.

‖ Sir W. Thomson, "Effects of Stress on Magnetisation," forming Parts VI. and VII. of his great series of Papers on the "Electro-Dynamic Qualities of Metals" (*Phil. Trans.* 1875, 1878; Reprint of Papers, Vol. II., pp. 332—407).

* *See* Wiedemann's *Elektricität*, Vol. III., § 762, *et seq.*

† Reprint, Vol. II., p. 382.

‡ This and a number of the succeeding figures are taken from the Paper on the "Magnetic Qualities of Nickel" (*Phil. Trans.*, 1888, pp. 325 and 333), in one of which the author had the collaboration of Mr. G. C. Cowan.

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2 and 12 kilogrammes, corresponding to 5·5 and 33 kilos per sq. mm. respectively. The effect of tensile stress in depressing the magnetisation curve is very marked. With no load the maximum susceptibility is fully 15, with 2 kilos it is only about 8, and with 12 kilos the resistance to magnetisation has become so great that the maximum of susceptibility has not been reached even by raising H to 100 C.-G.-S.

Great as the effects of stress are upon the magnetic susceptibility, they are even greater on the retentiveness. In the same figure (95), three curves shown have been drawn in broken lines, thus: — - — - —, to show the residual magnetism that was found on withdrawing H at each of a series of stages during the process of magnetising under each load. The presence of load reduces the residual magnetism even more than it reduces the total induced magnetism. The residual value of I, after applying a force, H, of 100, is nearly 300 when there is no stress; under 2 kilos, it is only reduced to 150; and under 12 kilos it is only 16. The proportion of residual to total induced magnetism has a maximum of 0·76 under no load; but under 2 kilos it is reduced to 0·61, and under 12 kilos to 0·19. The amounts of magnetism which disappear when H is removed, under various loads, form a greater proportion of the whole the more the load is increased, although (owing to the reduction in the total magnetism) the absolute amount that disappears when a strong force is removed is greater for a small load than it is for no load, and then less again for a large load.*

The presence of a *small* amount of load may, therefore, be said to *increase* the susceptibility of nickel with respect to that part of the magnetism which comes and goes when H is alternately applied and renewed, provided H is strong; when H is weak the effect of any load is only to reduce this susceptibilty.

Fig. 96 gives the same results of a similar experiment in which the same piece of nickel wire, after being hardened, however, by a slight amount of stretching beyond its limit of elasticity, was magnetised under a succession of pulling loads, ranging up to 18 kilos., or about 50 kilos. per sq. mm. With no load the maximum susceptibility of this hardened wire was about 8. Under the highest load the susceptibility was practically constant within the range of H used (up to 100 C.G.S.), and its value was only about 0·5 (permeability about 6·3). In this condition of stress the residual magnetism is almost *nil*. The dotted lines in this figure show the effect of gradually removing the strongest value of H which had been reached in the process of magnetising; they illustrate well how the residual magnetism becomes smaller, not only absolutely, but as a fraction of the whole magnetism, as the load is increased.

(To be continued.)

* This fact has been noticed independently and commented on in a recent Paper by H. Tomlinson (*Phil. Mag.*, May, 1890).

ON THE ELECTRO-DYNAMICS OF STATIONARY BODIES.*

BY H. HERTZ.

(Continued from page 637.)

PART B.

Explanation of the Phenomena by means of the Fundamental Equations.

We shall divide the phenomena to which our equations refer into three distinct groups—static, stationary or steady, and dynamic. A phenomenon can only be considered static or steady when the electric and magnetic forces do not change with time; and it is thus necessary, in these two cases, for the first members of equations (10) and (11) to disappear. For static phenomena it is, in addition, necessary that no variation shall occur in any of the quantities defining the state, and thus no transformation of energy can arise. For this to be the case, the values of u, v, and w must be zero.

Static Phenomena.

On substituting zero for u, v, w, in (11), and also for the left-hand members of each of the equations (10) and (11), we notice that the equations divide themselves into two distinct groups; the first of which (10) refers to electro-statics, and the other (11) to magneto-statics.

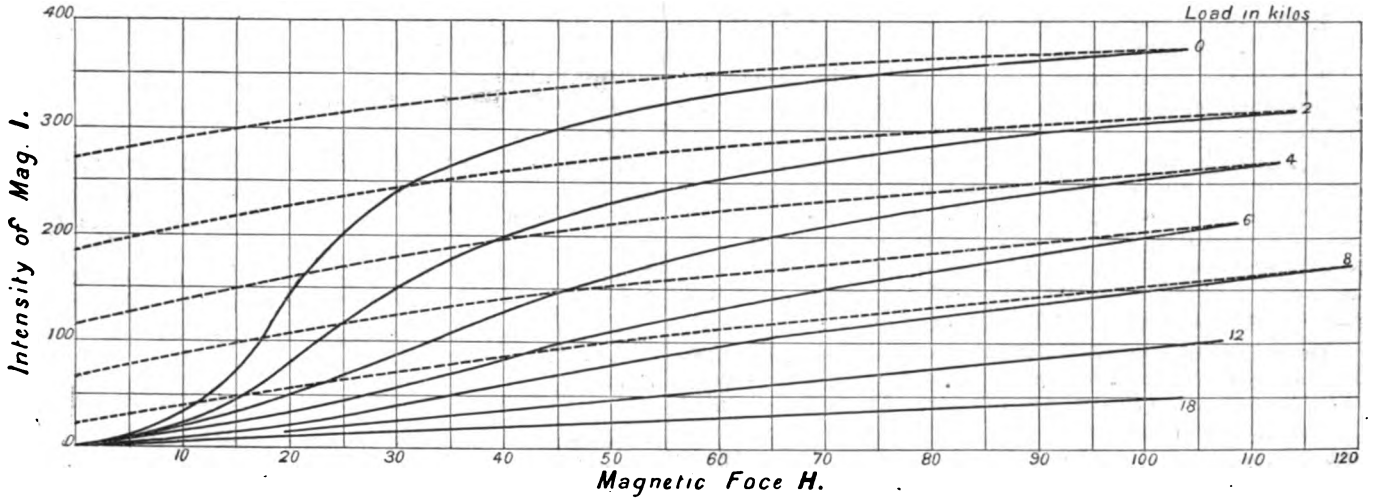

Fig. 96.—Nickel Wire hardened by stretching, magnetised under various amounts of longitudinal pull

Electrostatics.—For good conductors the forces X, Y, Z must be zero, since otherwise currents would be produced. For bad conductors equations (10) reduce to

$$\frac{dZ}{dy} - \frac{dY}{dz} = \frac{dX}{dz} - \frac{dZ}{dx} = \frac{dY}{dx} - \frac{dX}{dy} = 0,$$

and it follows that a potential ϕ exists, for which

$$X = -\frac{d\phi}{dx} \qquad Y = -\frac{d\phi}{dy} \qquad Z = -\frac{d\phi}{dz}. \quad (26)$$

The function ϕ is, in general continuous, since the forces are generally finite. It must be constant throughout a good conductor; and the tangential component of the force must be the same on the two sides of a surface separating two media.

If the quantity of "true" electricity in a unit volume be ρ_p, we see from (17) and (8), and the expressions for X, Y, and Z, given above, that

$$\frac{d}{dx}\left(\epsilon\frac{d\phi}{dx}\right) + \frac{d}{dy}\left(\epsilon\frac{d\phi}{dy}\right) + \frac{d}{dz}\left(\epsilon\frac{d\phi}{dz}\right) = -4\pi\rho_p;$$

since in (8) we may put $\epsilon_{11} = \epsilon_{22} = \epsilon_{33} = \epsilon$, and the other coefficients are zero.

* An abstract of a paper published in the "Nachrichten von der Kœniglichen Gesellschaft der Wissenschaften," for March, 1890; and reprinted in *La Lumière Électrique*, July, 1890.

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For free ether we may put $\epsilon = 1$, and the volume density of "free" electricity being denoted by ρ we obtain

$$\Delta\phi = \frac{d^2\phi}{dx^2} + \frac{d^2\phi}{dy^2} + \frac{d^2\phi}{dz^2} = -4\pi\rho. \quad . \quad . \quad (27)$$

This equation reduces to $\Delta\phi = 0$ for all parts of space which are uncharged. The function ϕ, which satisfies these equations, is—

$$\phi = \int \frac{\rho}{r}\, d\tau \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

where r is the distance of the point considered from the volume element $d\tau$, which is charged to a density ρ; and this is the well-known expression for the potential at a point due to surrounding charged bodies. Coulomb's law of electric attraction and repulsion follows at once, since the force in the direction r is $-\frac{d\phi}{dr}$, and this by differentiation is seen to be inversely proportional to r^2.

The expression given in (12) for the electric energy—

$$\frac{1}{8\pi}\int (X\,X_p + Y\,Y_p + Z\,Z_p)\, d\tau$$

can by suitable transformations be reduced to—

$$\frac{1}{2}\int\int \frac{\rho_p \rho}{r}\, d\tau\, d\tau$$

Magneto-statics.—All the remarks made in the preceding section about the electric forces can be repeated with very slight modification with reference to the magnetic forces. There are, however, certain points of difference.

1. The distinction of bodies into conductors and non-conductors does not exist.

2. With the exception of bodies exhibiting the phenomena of permanent magnetism the "true" magnetic density is everywhere zero.

3. Although the dielectric constant ϵ of all known bodies is greater than 1, the magnetic constant μ of a great number of bodies is, on the contrary, less than 1. Bodies are called paramagnetic or diamagnetic according as the value of μ for them is greater or less than 1. The surface density of "free" magnetism on a bounding surface is proportional to $(1-\mu)$, and is thus of opposite sign for the two classes of bodies.

The science of magneto-statics acquires a special significance, because iron and steel, the most important substances dealt with, only obey the theory very roughly. The polarisation of the particles is in part independent of the acting forces, and is not determined by a single directed quantity. The relations are, moreover, no longer linear, and thus these substances must be regarded as outside the scope of the present theory. We may, however, for theoretical purposes, replace them by two imaginary bodies; perfectly soft iron, and perfectly hard steel. These are defined as bodies obeying the equations, and having a coefficient μ, which is very large indeed for soft iron, and equal to unity for hard steel.

Phenomena of the Steady State.

In bad conductors, as soon as the steady state is established, the same conditions hold as for static phenomena. For homogeneous conducting bodies, equations (10), (11) and (9) take the form

$$\frac{dZ}{dy} = \frac{dY}{dz}, \quad \frac{dX}{dz} = \frac{dZ}{dx}, \quad \frac{dY}{dx} = \frac{dX}{dy} \quad . \quad . \quad (29)$$

and

$$\left.\begin{aligned} \frac{dM}{dz} - \frac{dN}{dy} &= 4\pi A\, u \\ \frac{dN}{dx} - \frac{dL}{dz} &= 4\pi A\, v \\ \frac{dL}{dy} - \frac{dM}{dx} &= 4\pi A\, w \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (30)$$

$$u = \lambda (X - X'), \quad v = \lambda (Y - Y'), \quad w = \lambda (Z - Z'). \quad . \quad (31)$$

From (30) we obtain by differentiation

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0 \quad . \quad . \quad . \quad . \quad . \quad (32)$$

And the modification of this at every separating surface can be shown to be

$$(u_2 - u_1)\cos(n,x) + (v_2 - v_1)\cos(n,y) + (w_2 - w_1)\cos(n,z) = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

The equations 29, 31, 32, and 33, determine a system without reference to the magnetic forces, which may therefore be left out of account. When the components u, v, w of the current are found, it is easy, by means of equations 30, to obtain the magnetic forces exerted by the current.

Distribution of Steady Currents.—From (29) we conclude that the forces X, Y, Z, are the differential coefficients, with the sign changed, of a potential function ϕ. This is true even within a good conductor, and it follows from this, and from 31 and 32, that at all points we have

$$\frac{d}{dx}\left(\lambda\frac{d\phi}{dx}\right) + \frac{d}{dy}\left(\lambda\frac{d\phi}{dy}\right) + \frac{d}{dz}\left(\lambda\frac{d\phi}{dz}\right) = -\left[\frac{d}{dx}(\lambda X') + \frac{d}{dy}(\lambda Y') + \frac{d}{dz}(\lambda Z')\right] \quad . \quad . \quad (34)$$

At the surface separating two media this equation takes the form

$$\lambda_2\left(\frac{d\phi}{dn}\right)_2 - \lambda_1\left(\frac{d\phi}{dn}\right)_1 = -\Big[(\lambda_2 X'_2 - \lambda_1 X'_1)\cos(n,x) + (\lambda_2 Y'_2 - \lambda_1 Y'_1)\cos(n,y) + (\lambda_2 Z'_2 - \lambda_1 Z'_1)\cos(n,z)\Big] \quad (35)$$

If one of the media is conducting, we have

$$\left(\frac{d\phi}{dn}\right)_1 = 0 \qquad X'_1 = Y'_1 = Z'_1 = 0$$

and if, under these circumstances, we integrate ϕ along the normal n, we have

$$\phi_1 - \phi_2 = \int [X'\cos(n,x) + Y'\cos(n,y) + Z'\cos(n,z)]\, dn. \quad (36)$$
$$= \phi_{12}$$

If the integral is taken across an infinitely thin bounding layer between two media, we may obtain a finite value for the integral, even though the forces X', Y', Z' are infinite throughout the layer, and in this case ϕ_{12} may be called the electromotive force of contact between the two media. Equations (34) and (35) show that $\Delta\phi = 0$ within a good conductor, $\lambda_1\left(\frac{d\phi}{dn}\right)_1 = \lambda_2\left(\frac{d\phi}{dn}\right)_2$ at a surface separating good conductors, $\frac{d\phi}{dn} = 0$ at a surface separating a good conductor from a bad one.

These equations refer to conductors in three dimensions. When linear conductors are considered the modified equations are very simple to use, and by employing them we may readily deduce the definition of resistance, the law of Ohm, and Kirchoff's laws.

(To be continued.)

THE SUSPENDED COIL IN CABLE WORK.

BY E. RAYMOND BARKER.

In 1887 I was engaged in experimenting at Madeira with a view to arrange a mirror suspension which, whilst sufficiently heavy and sluggish to be unaffected by jerky vibrations, due to gas bubbles from a troublesome cable fault, would be sensitive enough to give fair signals in response to firm manipulation of the distant station's key. I was endeavouring, in short, to evolve an instrument sympathetic to firmly transmitted signals, but the reverse to sudden vibrations arising from a fault. A brief account of the experiments and the results achieved may not be uninteresting or uninstructive.

Tiny Thomson mirrors, with short delicate suspensions, we found far too sensitive to vibratory influences, although they gave capital signals when the fault happened to be quiet, which was but seldom. It is interesting to watch the behaviour of a fault. There is, first of all, a slight but almost constant vibration of the "spot," which, however, scarcely interferes with

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signalling. The same cannot be said of what follows. The slight vibration dies away, whilst the signals rapidly increase in size and clearness, when, suddenly, the emission of a gas bubble at the fault gives a violent jerk to the "spot," which again settles down with a shiver most bewildering to the mirror reader.

Unfortunately for the experiments (*pace* B. S. T. C. !) the fault was cut out before we could give a thorough trial to a new arrangement, which consisted of a long-range mirror on a 500ω coil, the latter hung between the poles of a strong permanent magnet, and kept in position by fibres and weights, as in Thomson's recorder. Experiments, however, show that :—

1. This instrument approaches very near to what is wanted, and has an action which tends greatly to smooth off jerky vibrations, while readily responding to battery impulses.

2. It is a capital "all-round" mirror, for one adjustment suffices for signals from cables of very unequal lengths. The Madeira—St. Vincent sections of the Brazilian Submarine Company's cables are roughly twice the electrical length of the Madeira—Lisbon ; yet the suspended-coil mirror answers equally well on all, without alteration of suspension.

3. Notwithstanding the great comparative weight of coil and mirror, and the general stiffness and rigidity imparted to the

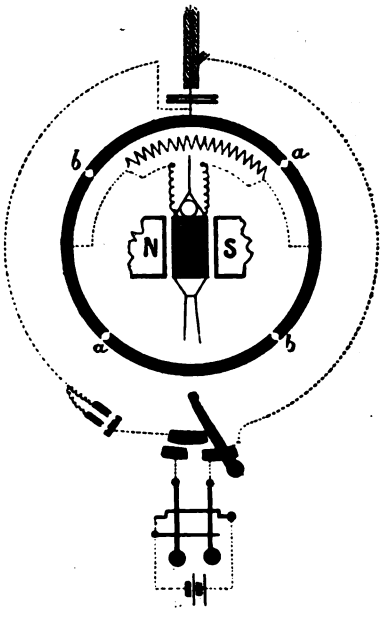

Fig. 1.—Diagrams of Connections of S. C. mirrors.

signals by the lower bifilar suspension and weights, the instrument, as a signalling mirror, is more sensitive than the Thomson.

4. In a test comparing a Thomson long-cable mirror of 3,000ω with a S.C. mirror of 500ω, range of mirrors being one metre, the current giving one division on test scale, for Thomson's mirror was ·0017 milliampere, and for S.C. mirror ·00089 milliampere. That is to say, the S.C. mirror is roughly twice as sensitive as Thomson's. The instruments were tested just as they stood, and both might have been more sensitive.

Such sensitiveness as that here shown is certainly not necessary. In fact, for mirror signalling, nothing could be superior to the Thomson, which simple, sensitive, and portable, is an ideal instrument. The writer only wishes to show what the S.C. mirror is capable of, and the advantages attaching to its use under certain conditions.

Fig. 1 shows connections of our S.C. mirror. They are made to give sending signals as a check on key and battery. There are two low-resistance shunts adjusting out-going signals to high and low battery powers. The poles and coil protrude upward through the table, a small glazed aperture in wooden cover permitting projection of the "spot" in a radius lengthways with the table. Reading can be carried on either from scale or from the wall opposite to the clerk, as he sits square with the table. In the latter case, the mirror throws the "spot" on to a looking-glass, where it is again projected at right angles on to the wall. Also a large convex lens may be used, which gives a "spot" 1ft. high, read with ease from the far end of the room. The signals on wall being reversed to what they are on scale, the coil and receiving-shunt are joined through a reverser which alters direction of current at will. There is also a sloping desk, supporting a message pad, on to which the "spot" can be thrown for self-writing, which is further facilitated by the "spot" being projected, at will, across entire pad. This instrument would be excellent for a "leak" station, which breaks in at intervals, and adjusts sending and receiving conditions to varying lengths of cable, and number of stations in circuit, and where one reliable permanent mirror is required, and nothing more.

In the Brazilian Submarine Company the mirror is now of the past, and the recorder is universal. Last year, however, occasion offered a new experience with the S.C. mirror. A

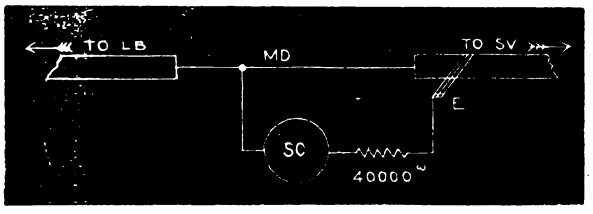

Fig. 2.

week's experiments were made for through working between St. Vincent and Lisbon (Carcavellos) with a leak of about 40,000 ohms at Madeira. In leak circuit, Madeira (M.D.) had an S.C. mirror as in Fig. 2.

With St. Vincent (S.V.) sending, a Thomson mirror with ordinary suspension showed the slightest perceptible movement, but no readable signals. The Lisbon (L.B.) signals were plain, with S.C. mirror substituted. Signals from S.V. were perfectly readable, whilst with L.B. sending, S.C. had to be heavily shunted with key pressed down or raised, according as S.V. or L.B. transmitted. Signals from L.B. being, of course, reversed to those from S.V., we arranged, as in Figure 3, signals, as seen on the reflection of scale in the looking-glass, were reversed to real signals on scale itself. So we read from scale or looking-glass, according as signals come from L.B. or S.V.

Ten years ago the writer designed a relay for submarine cables of medium length. It was merely the suspended coil in a magnetic field with a projecting tongue to close two local

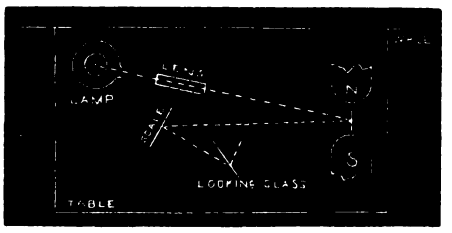

Fig. 3.

circuits after the manner of Bright's bells. Had this been practicable, automatic translation would have followed as a matter of course ; but the idea was abandoned by the writer on his hearing that Mr. De Sauty had already tried the suspended coil as a cable relay, but without success. Three years ago the writer again experimented with the S.C. as a cable relay. (*See* Fig 4.) P P are brass projections adjustable, by micrometer screws, at right angles to the aluminium tongue *t*, which carries a cross-piece *c*, the latter having needle-point ends. On P P are platinised depressions carrying globules of mercury *m m*, which act as contacts on both sides of *c*, and which, by capillary elevation, stand well above the surrounding brass, thus permitting *c* to swing against them free of P P. + and − impulse, through S C, cause corresponding contacts between *c* and *m m*-which bring into local circuits the sounders S^1 S^2, which, differing in tone, can be easily read.

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Experiment showed that although with customary battery and condensers it was possible to receive distinct words through our Madeira—Lisbon sections, yet with anything approaching to fast working, make-and-break between *c* and *m m* could not be relied on, even with anti-speaking devices between *c* and *m m*.

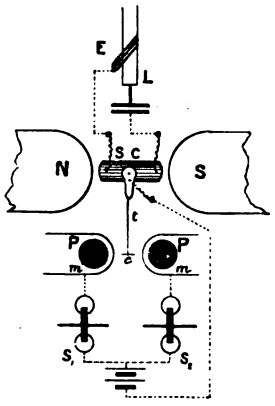

FIG. 4.—S. C. Relay

With St. Vincent sending at ordinary speed we obtained only confused beats on the sounders, without any perfect signals, it being impossible to adjust *m m* to the varying zero on this comparatively long cable. As an alarum relay, however, this instrument would work anything, from a bell to a mid-day gun or time-ball.

THE COMPENSATION OF ALTERNATING-CURRENT VOLTMETERS.*

BY J. SWINBURNE.

In 1887 I had the honour of bringing before this Section several methods of compensating voltmeters and resistance-bridges for variations of temperature. Wires with different temperature co-efficients were used, by which means errors from change of temperature can be avoided. Methods of compensating wattmeters for the errors inherent in them were also explained. The present communication relates to a somewhat analogous arrangement for compensating alternating voltmeters for changes of frequency.

It is much more easy to make a current indicator for alternating than direct currents, for troubles from hysteresis do not come in, and the slight tremble makes the moving part hang freely. If it is attempted, however, to use such an instrument as a voltmeter, the self-induction makes the reading far too low, and the error varies with the frequency.

To get over this trouble, a voltmeter may have a non-inductive, or nearly non-inductive, resistance put in shunt to its active coil. A coil with an adjustable iron core is then put in shunt to the active coil, this shunt coil having a very much larger time-constant. Though both coils have iron cores, they have open magnetic circuits, so they have practically constant co-efficients of self-induction. When the frequency increases, the current through the whole instrument under a given pressure falls; but the back pressure of the shunt coil increases more rapidly than that of the active coil, so that it takes less than its share, while the active coil gets a larger share of the reduced current; the actual current, and therefore the reading, in it remaining constant. The instrument is calibrated with a direct current. An alternating current is then put on, and the core of the shunt coil regulated till the readings agree with those of the direct current.

A similar effect might be obtained by putting a condenser in shunt to the non-inductive series resistance; but it does not look so promising, and I have not gone into the size of condenser needed in practice.

* Paper read before the British Association in Section A Leeds, September, 1890.

"SILVERTOWN" DYNAMO AND "GLOBE" COMPOUND ENGINE.

This dynamo, which is capable of giving a continuous output of 350 amperes, and 104 volts, at 300 revolutions, has been designed for coupling direct to a high-speed engine, and is so coupled to a Globe compound engine, having cylinders 8½in. and 15in. diameter, by 8in. stroke The magnets are of the single horse-shoe type, with pole pieces at the lower end, each vertical limb carrying a metal bobbin, on which is wound both series and shunt wire. The armature, which is of the ring type, has its core built up of thin annealed charcoal iron discs, insulated from one another, every alternate disc having a thin coating of special ebonite cured on to a thicknes of 3 mils. The discs themselves are 32 mils thick. This gives 91 per cent. of iron and 9 per cent of insulation, or, allowing for irregularities in the plates, 88 per cent. may be reckoned upon in practice. The discs are key-holed, and carried by a four-armed gun-metal spider, which in turn is securely keyed to the steel shaft. The armature winding consists of one layer of insulated strand cable, wound and connected on, in the ordinary method, to the commutator, which is built up of hard drawn copper segments, insulated with mica, and carried at each end by insulated gun-metal rings, fitting into grooves turned in the commutator. The insulation of these rings is obtained by the use of ebonite, which is cured on to a thickness of about one-eighth of an inch; and it has been found that this has given much more satisfactory results than the old method of having separate insulating pieces. The rings fit on to a gun-metal sleeve, bored to fit the shaft, and the whole commutator is screwed up tight by nuts on this sleeve, so that it is complete in itself. There are three brush-holders on each spindle, each fitted with separate adjustments for pressure, and with hold-off catches. The brushes and holders are made of ample section, and each brush-holder is connected by a separate flexible conductor to the terminal board of the machine, to avoid the necessity of collecting the current through the contact between the holder and the spindle on which it is carried. The dynamo has been designed for continuous running in an engine-room, the temperature of which is somewhat over 100° Fahr, and the rise of temperature has therefore been kept low; an actual test made by placing the thermometer on the armature directly the machine was stopped, and noting the highest temperature recorded by the thermometer, showing a rise of 25° Fahr.

ELECTRIC LIGHTING AND FIRE INSURANCE RULES.*

BY WILSON HARTNELL.

The early inexperience and ignorance of many who undertook electric lighting, and consequent accidents, rendered some guidance and restrictions absolutely necessary for protection against fire. Much is left to the conscience or ability of the contractor, which is unjust to those who abide by the best rules.

Such rules should contain the minimum that is necessary, and this should be strictly enforced.

In regard to conductors my first point is to show that any attempt on the part of the insurance companies to determine a fixed current density is useless, vexatious, and scientifically wrong. For any electric light installation it is necessary to limit the fall of potential in the more distant lights. This can only be done by so limiting the current density that there is not the remotest chance of fire from over-heating of the wires. If, however, an arbitrary rule, such as 1,000 amperes per square inch, be insisted upon, this rational principle of lighting cannot be adopted. It is, of course, necessary to adopt some limits of currents, but these depend upon the sizes of the wires, as it is easily shown by experiment and reasoning that the larger the cable the less must be the current density. *However small* the current, the smallness of the wires must be limited. For example, No. 20 S.W.G. is perhaps the smallest size that should be used for fear of mechanical injury. In mansions, &c., where the first cost of wiring is of less consideration, and also where the wires are placed out of sight, No. 16 S.W.G. may be the limit of smallness. That wires can be made

* Abstract of a Paper read in Section G, at the British Association, Leeds, September, 1890.

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red hot by electricity, and give rise to fires, was one of the most obvious facts thrust upon the notice of the Insurance Companies, and apparently almost the only one they could imagine or comprehend. This danger has been greatly magnified. It is, moreover, the danger most easy to absolutely abolish by judiciously arranged cut-outs.

In order to prove my points experimentally, I have provided for a current of 250 amperes at 110 volts dynamos.

The smallest wire used in electric lighting is the twin flexible wire, equal in section to that of No. 22, S.W.G. It usually carries one lamp and consists of 23 strands, 6 mils diameter. My first experiment shows that one strand only taken out of 23/40s and 6 mils diameter will suffice to light one 110 volt 16 candle-power lamp requiring about ·58 amperes. The whole pendant of 23 such strands is therefore absolutely safe with one lamp. The current density in this small filament is 20,500 amperes per square inch. By further experiment I now show that this filament will carry three such lamps, say 60,000 amperes current density, without being hot enough to burn anything. It becomes dull red hot with five lamps and a current density of about 100,000 amperes per square inch.

Experimenting with the complete 23 strand twin wire, it will be seen that it easily carries eight or ten lamps. The 1,500 candle-power Sunbeam lamp at 35 amperes gradually destroys the insulation. It is equal to 60 16 candle-power lamps. It may, therefore, be pronounced absolutely safe with two or three 16 candle-power lamps. The smallest solid wire used iu electric lighting is No. 20 =36 mils, which at 2,000 amperes per square inch would carry one ampere, say two lamps, but would seldom be used for more than one lamp. No less than about 80 lamps or 46 amperes are necessary to destroy it. No. 16, at 2,000 amperes to the square inch, would carry six lamps, but is here shown to be comparatively cool with 33 lamps.

These experiments on the smaller wires have demonstrated that there is not the most remote danger of fire with the currents ordinarily used, and therefore for Insurance Companies to fix a current density is vexatious, and cannot secure safety.

Fusible cut-outs seem to be regarded with some mistrust. The second point I desire to establish is that by their means the mains and branches may be absolutely protected from danger by fire from excess of current. The highest current will be required to melt a cut-out when it is short, and itself and connection cold—when it is longer or covered up, and heated gradually, a lower temperature melts it. Wires are efficiently protected by fusible wires of the same diameter; and this is the only point that Insurance Companies need trouble about. Experience with cut-outs shows that if only a very small margin be allowed they are after a while liable to melt with the working current, apparently from deterioration of contacts and gradual accumulation of heat.

Cut-outs must be placed in conveniently accessible positions. The subject of the construction and position of cut-outs is most important, but would require a Paper to itself. Experience has led me to regard good cut-outs, properly fixed and wired, with almost implicit confidence as protecting the wire. Cut-outs are no protection against heating and sparking from imperfect or broken contacts.

The insulation required for telegraphic work and that for electric lighting work are not necessarily the same. In the former the wires extend for hundreds of miles, and the storage of energy in the batteries is both costly and very limited. In electric lighting the wires are short and power abundant. The chief object of electric light insulation is, therefore, safety; and this safety, like that of a steam boiler, should be not for one or two years, but for as many years as possibie. Durable insulation is, in my opinion, of far more consequence than high insulation. Naked wires on insulators (where practicable) are the best and most imperishably insulated. Vulcanised india-rubber gives the highest insulation for covered wires. Exposed to the air, vulcanised rubber often cracks, and more or less perishes in a few years. When held together and protected from the air, as it is in the cable, it may last much better. For damp places vulcanised rubber is indispensable, or some waterproof insulation.

A very important point, which experience alone can determine, is what insulating coverings will remain most trustworthy at the end of ten, twenty or thirty years.

The greatest protection, in my opinion, is to be obtained by using good material and good workmanship throughout, and not trust to merely insulation tests only. It is not fair to demand very high insulation tests for wire without also specifying the quality of insulation; because a single rubber wire, or possibly a wire innocent of india-rubber, may test as well as vulcanised wire in dry weather, so that the covering required is indeterminate. It must also be remembered that although the insulation of the bases of the switches and cut-outs is high, yet in the aggregate (if the switches, &c., be numerous) they will reduce considerably the total insulation. If the test be between the positive and negative wires the lamp fittings will greatly reduce this; so would also the twin wires for the pendants.

The casings are mechanically useful to protect and support the wires; they have the disadvantage, putting it from an insurance point of view, of concealing it. The space between the grooves has now been reduced to a reasonable width; at the same time it seems unreasonable to put all qualities of wire on the same footing. It seems to have been forgotten, curiously, that when switch wires, say positive, are laid on a positive wire and switched off, they become negative. The possible current through them is no doubt limited to that which would go through the lamps. The use of varnishing casing seems very doubtful; if the place be not damp it can be of no service; if it be damp, then a wire that will stand damp ought to be used. Non-inflammable paints to prevent the casing taking fire seem to me ridiculous. There can be no remote risk of fire in the casing if the work be properly done.

Of switches very little need be said. On the main sections double-pole switches are convenient; but on the branches double-pole switches and double-pole cut-outs, by the extra expense and complication they would entail, would more than defeat any imaginary advantage urged by their advocates.

The grievance of ill-framed and conflicting fire insurance rules is not only that they interfere with the carrying out of the work in the manner best suited to the circumstances, but there is difficulty in knowing what is required. By insisting, or appearing to insist, on a certain class of material, certain conditions, &c., in one case, and passing very different things in another, there is a further difficulty in not knowing what, by chance or caprice, they may accept. Meantime, those who require the electric light, and know nothing of the matter, are still further bewildered, and are apt to choose the work which is the least expensive, so that the insurance companies defeat the professed object. In conclusion, I would most strongly urge that the rules of the Institution of Electrical Engineers, with, perhaps, a few additions, be accepted by all the fire insurance companies.

DISCUSSION.

Mr. W. H. PREECE said that he did not go the whole way with Mr. Hartnell in attacking the fire insurance offices. They had taken infinite pains to secure accurate rules, and their sole object was not to throw obstacles in the way of users of electricity or difficulties in the way of contractors; but to secure their own purses from being drawn upon too much by accidents that were really remedial. One of the most frequent sources of danger in houses was the existence of a bad joint, which generated heat. A point not touched upon by Mr. Hartnell was the use of wood casing in damp places. He had seen two or three very nasty instances where a possible accident might have occurred through a leakage crossing the casing, which had become damp from moisture, falling over it. The wood had become carbonised; it had, in fact, become a conductor; heat had been generated, and the wood itself had been practically burnt.

Sir FREDERICK BRAMWELL said it appeared to him that the heat which was developed in a wire was simply due to the destruction of energy by the resistance of the wire to the passage of the current, and that the result would be cumulative, and that the temperature would continue to increase until the dissipation of heat from the surface of the wire either in contact with the air or in contact with some other material carries off the heat as fast as it is generated, and there is no further increase in temperature. If that be the right way of looking at it, then it seemed to him wrong to suggest that any particular size of wire could carry with safety any number of amperes, without knowing the incidents of the surroundings of that wire.

Major-General WEBBER said the rules drawn up by the committee formed by the Institute of Electrical Engineers were rather rules for guidance as to principles; and it had been left to the insurance companies themselves to draw up their own bye-laws, as they might be called. He believed that the use of casing, except in certain positions, would gradually die out.

Mr. KAPP said he was not prepared to go with Mr. Hartnell in his condemnation of a current density limit. The current density rule was a very unscientific one, but in practice it worked very well, as people were in the habit of employing the bellhanger or somebody else round the corner who would not understand a more scientific rule. He agreed with General Webber in regard to the casing.

Mr. TROTTER said the heating of very large conductors was perhaps a subject some times to be considered, but the heating of small wires hardly ever need be entertained. As for putting large currents through small wires, which Mr. Hartnell had done, he thought that the experiments were most misleading. He should be sorry to see a No. 20 wire used in a house; he was strongly opposed to using a No. 18 wire, and thought that a No. 16 wire the smallest that should be used in such work.

Mr. HARTNELL, in reply, said that he thought the rules of the Institution of Electrical Engineers were immensely superior to those adopted by the Fire Insurance Companies. He should like to see the British Association, as they did in the case of electric standards, introduce some national code of laws, founded on principles for protection from fire, giving the minimum that was required: and that that minimum should be enforced. In regard to Mr. Trotter's remarks, he had totally missed the point; he had shown by experiments that the wires could carry with perfect safety much larger currents than those permitted by the fire offices.

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The Electrician.

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THE POSTMASTER-GENERAL'S ANNUAL REPORT.

Whatever may be the departmental reasons for treating the Telegraphs as a separate branch of the Post Office the fact that they continue to be so treated enables us to note from year to year the growth of that part of the business which has most interest for our readers. As usual, the POSTMASTER-GENERAL'S Report, just issued, for the twelve months ended 31st March last, furnishes, with much particularity, the details of all receipts and expenses connected with the Telegraph Service quite distinct from the Postal Service accounts. For several years past we have failed to see the object of continuing this practice, unless it were to convince certain unbelieving reformers that the Telegraphs have never yet been worked at a profit. But if that is the true explanation, we should like to know why the same plan is not adopted in respect to some other descriptions of Post Office undertakings—the Parcel Post, for example. The Parcel Post is described in this year's Report as growing steadily "in a satisfactory manner"; but even from the meagre details set forth on page 4 of the Report it is plain that with half the receipts paid over to the railway companies the profits, if any, do not go to swell the Post Office revenue. As, however, the expenditure on this popular, but financially questionable, experiment has never been separated from that of the main business, the public are not made aware of the extent to which parcels are transmitted through the post out of pure benevolence. Not so the Telegraphs; every item of expenditure is paraded with an exactness which provokes the wondering inquiry how two businesses so intermingled as manifestly the Telegraph and Postal businesses are can have their accounts so squarely apportioned. The cost of keeping separate balance-sheets must from beginning to end exhaust

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a considerable sum of money; and unless there is some occult reason for keeping them asunder, the Postmaster-General might, one would think, usefully direct his attention to bringing about a real amalgamation of the accounts similar to that which has taken place between the respective services.

We have been led into making these observations partly through weariness of seeing repeated the oft-told story that the Telegraphs do not yet pay interest on the original outlay; and partly from a similar reiteration of complaints that certain portions of Telegraph business are conducted at a loss. The wording of the present Postmaster-General's Annual Report always leaves us in doubt whether his remarks on these points are intended as lamentation or as explanation. But in whatever way we take them they appear to us a waste of breath; for if Press telegrams and Railway telegrams are a grievous burden to the Telegraph Department, they ought either to be got rid of, or accepted in silence like many another burden which the Post Office has been saddled with, and has carried without a murmur. It naturally occurs to friends of the Telegraphs that the Post Office, which has a very broad back, could very well afford to carry some of the dead-weight under which its younger brother has so long been staggering. In other words, if the two services were united financially as they are administratively, there would be an end to these unavailing complaints, and the saving effected would probably go a great way towards removing all ground for them. Meanwhile it should never be forgotten that the annual profits of the Telegraphs have been spent on extending and perfecting the service, which is now the best-equipped and most efficient in the world—a result which the Department rightly considers of far more importance to the public than payment of interest on the purchase money.

Turning, however, to that portion of Mr. Raikes' Report which deals with the Telegraph statistics of the year 1889-90, it is noticeable that the increased prosperity of the country has had a marked effect on the revenue, the improvement amounting to £233,871, as against £137,016 for the year preceding. On the other hand, the expenditure is shown to have exceeded all previous years, and, indeed, nearly absorbs the increase in the receipts, the exact figures being £2,181,472, an increase of £212,148 over the expenditure in the previous year. Notwithstanding this additional outlay, the net revenue has exceeded by nearly £20,000 that of the year ended March, 1889, the deficit being reduced from £265,183 to £197,690. A sum of £27,370 has been this year expended in the conversion of the stock, representing capital expended in the purchase of the Telegraph system, thereby lessening the yearly interest by £27,000, which now stands, therefore, at £299,216, instead of £326,417 as heretofore. If this process be repeated, and the rate of present improvement in net revenue maintained, not many years ought to elapse before the Telegraph receipts will actually cover the current interest on its capital. When that time arrives, the one intelligible reason for keeping a separate set of accounts for the Telegraph Department will have disappeared, and the Post Office may then, perhaps, condescend to accept the Telegraph surplus as part of its own.

No material change appears to have taken place in the habits of the public, who continue to exhibit considerable smartness in curtailing their messages, the average payment for which is still a fraction below 8d. This is the standard which apparently it may be expected to maintain—rather less than more, however, as the economy of words will grow with practice even when economy of money is not sought after in such prosperous times as the present. Recent correspondence in *The Times* relating to short addresses, which are deemed insufficient by the Department, betray this tendency in a remarkable way. It is evident the writers of these indignant letters are often actuated as much by a desire to save themselves trouble as by any designs on the Telegraph revenue; and this being the case it would be idle to calculate on the average telegram ever exceeding its present limited dimensions. People will send more Telegrams, but they will not pay more for them; and the Postal Telegraph Department may as well recognise the fact by improving its methods of delivery.

In another direction a more conciliatory spirit has been shown, and has been appreciated to an extent probably not anticipated. Telegraph money orders, which were confined at first to less than a score of large towns, were extended early in the present year to all head and branch offices in the United Kingdom, with the result that in the first month of the larger experiment 1,769 orders were issued to the value of £6,262. When we remember that the cost of remitting money by wire is rather exorbitant, these figures show that the system is one which has met a real want, though nobody seems able to explain how it can arise so frequently. The acquisition of the continental cables has been rapidly followed by a large increase in the number of telegrams forwarded and received between this country and the continent, partly due to the reduction of rates, but largely, no doubt, to the improved working and extended facilities which are afforded under Governmental management. On this transaction the Postmaster-General has good reason to congratulate himself, and the public will not grudge him the credit that is certainly his due. As regards telephony the Report is singularly silent; but we can draw no conclusions from this circumstance, because probably none have as yet been arrived at by its author.

ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 648.)

§ 14. **Switch-Boards and Regulators.**—The switch-board arrangements in this system are particularly well devised. A switch-board is generally set up for each dynamo and for five or six feeders. The usual American practice is not to work the dynamos in parallel, although this is quite practicable, but to permit each dynamo to supply two or more feeding or primary circuits at full load, and then, as the load goes off, to group or gather together the feeders on to one or two dynamos in order to keep the working dynamos as far as possible fully loaded up. Figure 40 shows a switch-board arrangement (not, however, the newest form) for two dynamos and four primary lines.

Commencing at the bottom of the switch-board we see four rheostats. The two small ones at the centre control the field circuits of the exciters. It is the usual practice to provide each station having more than one dynamo with duplicate exciters, each having a capacity sufficient to charge the fields of all the alternate dynamos. Only one exciter is in use at a time, the other standing idle as a reserve. It follows, therefore, that the governing of the electromotive force of all the alternators is effected by an introduction of resistance into the field circuit of this exciter.

The control of the electromotive force of each separate alternator is effected by the introduction of resistance into the field circuits of these machines by the rheostats on either side of the

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middle ones. The small changing switches between the rheostats are for connecting either exciter with either dynamo at will, and for connecting the field circuits of both dynamos together. Over the rheostats are shown four sets of trunk wires, each consisting of two heavy parallel copper rods. Between each upper and lower set are three changing switches. The wires leading to the middle connection of the centre switch come from the No. 1 dynamo, whose current can be delivered to the upper or lower trunk wires at pleasure. The two outside switches of each triplet enable the primary wire attached to the centre connection of the switch to be put in connection with either trunk circuit at pleasure. Between the two sets of trunk wires are seen two multiple-arcing switches, which enable the dynamos to be run in parallel if desired, and a synchroniser or phase indicator is provided as described in connection with the Leghorn Central station (see § 9) to enable the dynamos to be put in parallel when in phase.

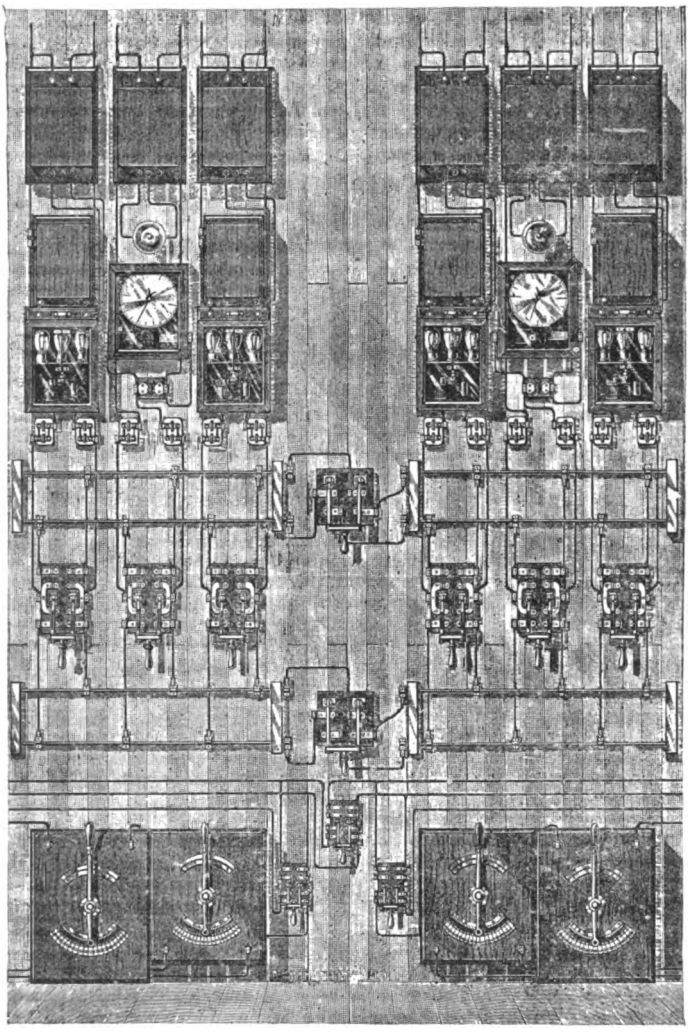

FIG. 40.—Westinghouse Switchboard for Two Dynamos and Four Circuits.

Over the trunk wires come a row of six safety catch-holders, each with double fuses and plug cut-outs. Over these safety fuses are four voltmeters, each with its attendant compensator above it. These voltmeters serve to measure the pressure at the far end of the line, and the compensator corrects the voltmeter reading for the fall in volts along the line. Between the voltmeters on the dynamo main comes the amperemeter. At the top of the switch-board is a row of small transformers, which serve to reduce the pressure for the voltmeter. It is easily seen that a large variety of possible changes are readily effected with a switch-board of this kind, and that it enables one attendant to regulate a number of feeding or primary circuits. In larger central-station switch-boards the arrangement is somewhat different. For each feeding or primary main there is a separate panel, and, by an arrangement of plug switches, any one of the whole battery of dynamos can be worked on to this feeder. Also, by a throw-over switch in the centre of this board, this feeder can be instantly thrown over on to any other selected dynamo. Hence it becomes the easiest operation to group, or collect, or change over the feeders from one machine to the other; and American practice has seemed to indicate that this arrangement is, on the whole, easier to operate than working the dynamos in parallel.

When several feeders proceed from one dynamo, and on these supply lines different consumption exists than in each of the primaries, the fall in volts may require adjustment from time to time. To introduce resistance into the feeder would be a

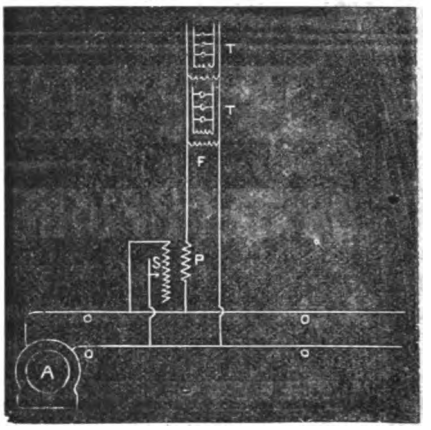

FIG. 41.—G. Kapp's Method of Regulating Electromotive Force at the termination of a feeder F. P is a primary coil in series with the feeder F, and S is a secondary coil in shunt off the omnibus mains O O. More or less of the turns of S are thrown into circuit as required.

very crude device; the necessary independent adjustment of the volts at the far end of the feeder can be better obtained by a method due to Mr. G. Kapp.* Let O, O, Fig. 41, be the omnibus bars from which the feeders start. The feeder F has in series with it one coil, P, of a transformer, the other coils of which is a shunt across the omnibus bars; by inserting more or less of

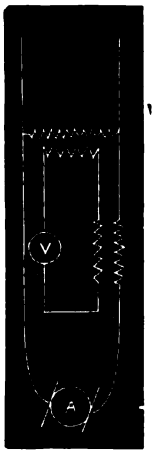

FIG. 42.

the turns of the coil S into circuit by a shifting contact, a little auxiliary volts are put into the feeder by the inductive action of the coil, which is in shunt across the omnibus bars. This regulating device may be so designed as to add, or be capable of adding, 50 to 100 volts to the 1,000 or 2,000 volts already on the feeder; hence, a movement of a lever enables the station engineer to adjust with great accuracy the volts at the far end of the feeder, and to do this for each feeder independently, even though all may be working off one dynamo. The arrangement employed for determining the volts at the far end of the feeder is essentially the same as the method already described in connection with the Ganz system. The voltmeter is in series with the secondary circuits of two transformers, one of which has its primary in series with the feeder circuit, and the other of which has its primary as a shunt across the feeder (*see* Fig. 42).

* See *Proc. Inst. Elect. Eng.* London, Vol. XVIII., p. 215, 1889.

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The electromotive forces of these two transformers are opposed to one another. Since the secondary electromotive force of the transformer in shunt is proportional to the primary electro-

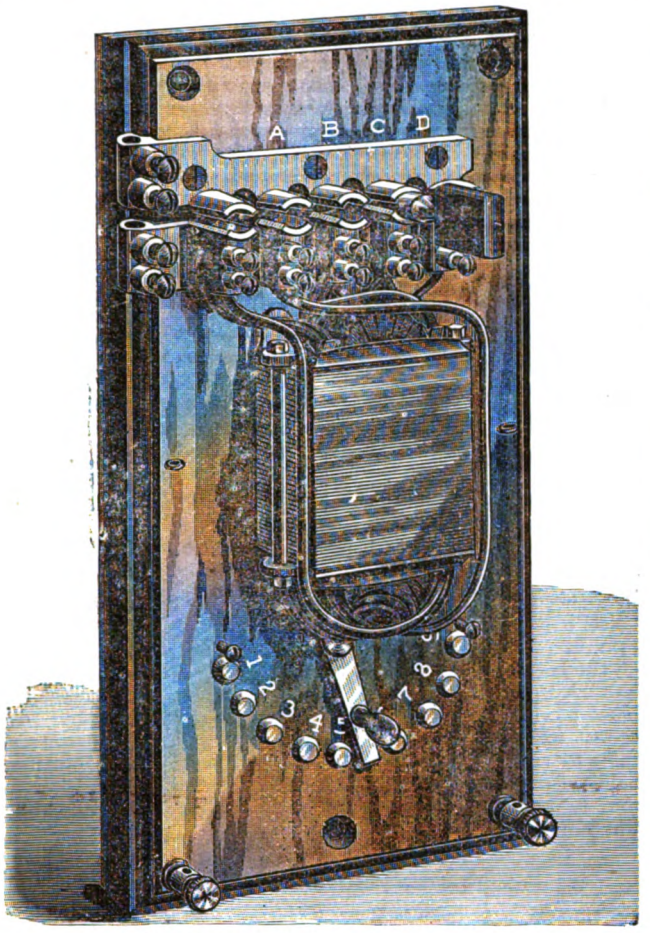

Fig. 43.—Westinghouse Compensator.

motive force, and since the secondary electromotive force of the transformer in series is proportional to the primary current strength, the difference between the two is proportional to V – R C, where V is the primary volt and C the primary current strength. As already explained, this difference is proportional to the pressure at the far end of the feeder, and by

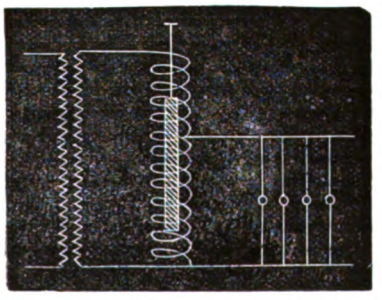

Fig. 45.

proper adjustment the voltmeter can be made to indicate this pressure, without any need for pressure wires run back to the station. In the Westinghouse system, the necessary transformers for this purpose are put together into a box and called a compensator (*see* Fig. 43); all that has to be done is to connect the voltmeter to the compensator.

In addition to the regulation of pressure which is carried on at the station, it is necessary at theatres and in houses to be able to adjust the working electromotive force on the lamp circuits. There are two neat devices used by the Westinghouse Company for this purpose, called stage and house regulators. The stage regulator, intended chiefly for the regulation of stage lights, is shown in Fig. 44. It consists of two connected coils of wire, with an iron core not quite so long as one bobbin sliding through both. One coil may be called the series and the other the shunt coil. The diagram below (Fig. 45) shows the mode

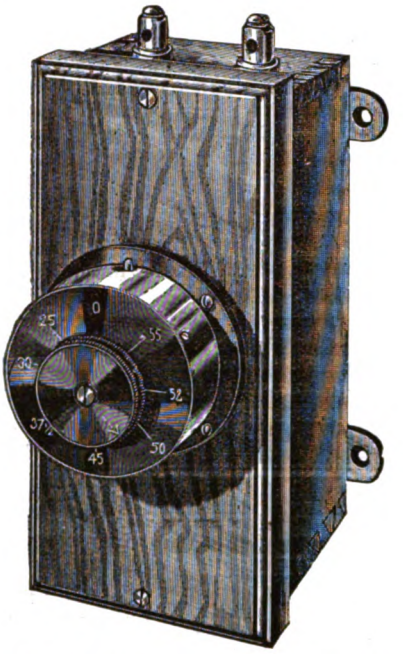

Fig. 46.—Westinghouse House Lamp Regulator.

of connection to the lamp circuit and transformer. When the iron core is pushed wholly within the shunt coil it bestows upon it such inductance that it blocks out all current through the

Fig. 44.—Westinghouse Stage Regulator.

shunt, and the lamps will be at their full brilliancy. On gradually drawing the iron core out of the shunt coil and into the series coil the inductance of the series coil is increased, and that of the other is diminished. Hence the current through the lamps is diminished by both actions, and the lamps become less bright.

A somewhat similar arrangement is provided for a house regulator. Across the secondary circuit of the house transformer is a single coil (*see* Fig. 46), and the several sections of this coil are brought up to a revolving contact. By turning a handle more or less impedance can be inserted in the lamp circuit. The coil also acts as an auto-converter, and can be made to raise the lamp volts slightly above the volts at the terminals of the transformer. The coils of the regulator which project as it were beyond the points *a b*, at which the transformer secondary circuit is joined in, have inductive electromotive force set up in them by the neighbouring coils, which, being added to the actual secondary or impressed electromotive force, between *a b*, make it possible to have the volts on the lamps actually higher than the secondary terminal volts at the transformer.

(To be continued.)

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ELECTRIC MOTORS IN WORKSHOPS.*

BY C. FREWEN JENKIN, B.A.

The author describes various applications of electric motors to drills, tube cutters, and cranes. He has used cast-steel in the construction of the field-magnets, and gives the results of tests of the magnetic properties of this material. Tests of two different qualities of castings show that cast-steel lies in an intermediate position between cast-iron and wrought-iron in its suitability for magnets. From the cheapness with which castings may be obtained in any complex shape, in order to simplify the framework of the motor, the advantages of cast-steel are important.

Among the factors which determine the design of small motors it is pointed out that a small armature can be easily wound for running with 50 volts, but becomes troublesome to wind for 150 volts; thus the size of the armature must be kept sufficiently large to make the winding fairly easy. As to whether the motor is to be shunt or series-wound; in a series-wound motor the magnets may be of any form desired, since the winding consisting of comparatively few turns of thick wire can be put on by hand. But in a shunt-wound motor it is almost essential, especially in high voltage machines, to make the magnet cores straight, so that the winding can be put on in a lathe. This difference in the shape of the magnets causes small shunt-wound motors to be heavier than series ones, since it is impossible to arrange them so compactly. Where the load varies much, the difficulty of governing series motors becomes very serious. This difficulty does not arise in shunt or compound-wound motors.

In a rough preliminary experiment on a common drilling machine, it was found that to drill a ⅜in. hole through Bessemer steel, at the rate of about a ¼in. a minute, took about one-fifth horse-power. The speed chosen for the electric drill was 60 revolutions per minute, running light, or about 45 loaded. The motor was designed to run at 3,000 revolutions, and a steel worm on the shaft was arranged to gear into a brass wheel on the drilling spindle. The armature was a gramme ring 4in. in diameter; it was wound with 480 turns of No. 18 for 50 volts, and 1,600 turns of No. 24 for 150 volts. There were 40 sections on the commutator. The magnets were wound with 9,800 turns of No. 27, the resistance being 332 ohms for working at 150 volts. Under a brake test, with the 50 volt armature, the results were:—2,950 revolutions, 26·6 amperes, 47·7 volts, B.HP. 1·05; efficiency, 59·2 per cent. Lightness was considered of greater importance than very high efficiency. The weight of the motor alone without the drilling spindle cannot be given quite fairly, since the magnets have been used to form part of the framing for carrying the drilling tackle. The weights of the different parts, so far as they could be taken to pieces, are as follows:—Magnets, bearings, and brushes, 32lb. 12oz.; armature, 8lb. 8oz.; boring tackle, 15lb. 4oz.; total, 56lb. 8oz. These figures bear out the claim made by the author for the advantages of cast steel over cast iron; and the general design of the drill shows how much more cheaply the parts can be cast than forged. This was a shunt machine. A ⅜in. hole could be drilled through a ⅜in. iron plate in 45 seconds, the electric power required being 0·732 horse-power.

The next motor that the author designed was for driving a small saw for cutting tubes out of boilers. The copper tubes in locomotive boilers have to be renewed from time to time, and the machine was designed to saw them off just inside the tube plate. A plug is fitted with two eccentrics. The saw spindle runs in a bearing in an inner eccentric, and is either central or eccentric in the plug, according to the relative position of the two eccentrics. The saw is brought into its central position while the plug is introduced into a tube end, and is then thrown out of centre, so that it cuts into one side of the tube. By turning both eccentrics together the saw is made to cut all round the tube. The magnets of the motor were curved, and were series wound. They were made from a single wrought-iron forging, on which were bolted two phosphor bronze brackets forming the bearings. The tests were not carried out at full load; they gave:—watts absorbed 2,600, B.H.P. 2 8, efficiency 71·7 per cent. The weight of the motor alone is 60lb. The armature is 5in. in diameter, and of the Pacinotti-Gramme type, with only $\frac{1}{32}$in. air space. It has 40 slots ½in. deep, and is wound with 840 turns of No. 19. Each magnet has 190 turns of No. 14. There are three times the number of turns on the magnet which are required for running at full load, 63 turns being then sufficient. The extra turns were put on to keep the speed moderate on light loads.

A 10 horse-power motor of the Manchester type was constructed for driving a travelling crane. In order to avoid sparking, a pair of small series-wound magnets were placed on opposite sides of the armature, so that their poles were on a horizontal diameter, and were over the section being short-circuited by the brushes. This method is described in Swinburne's patent, No. 6,754, 1887 (*The Electrician*, Vol. XXIV., p. 400). It was found to answer admirably and entirely prevented sparking, no matter how quickly the load was applied. The power required to drive the four belts on the crane was 2·85 horse-power. To lift eight tons at about 4ft. per minute, 6·5 horse-power additional were required, and to lift 4 tons at about 9ft. per minute, 7·0 horse-power. Traversing at 47ft. per minute took less than 1 horse-power. By arranging the motor to drive the rope by which the crane was formerly worked, it was found that there was a saving of 8·4 horse-power, or 43 per cent.

After the failure of several forms of friction gear a magnetic clutch was made in the form shown in Fig. 1. The flanges are used

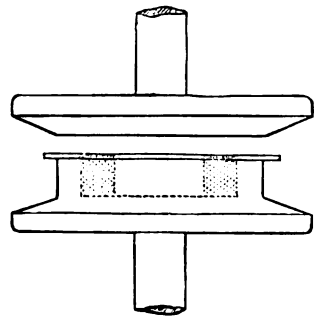

Fig. 1.—Magnetic Clutch.

in connection with the lowering gear. The diameter of the cylindrical portion is 6½in. A coil of 240 turns of No. 20 wire was put into the recess shown, and connection made to it by two brass rings on the back, against which two small brushes pressed. This clutch was tried, running at about 1,000 revolutions, and transmitted 8 horse-power satisfactorily, stopping and starting perfectly. In order to test what couple it could transmit with varying magnetising currents two levers were fixed to the two parts, and while one was held weights were hung to the other; but the coefficient of friction between the surfaces not being sufficiently constant the test was not satisfactory.

* Abstract of a Student's Paper, which was awarded the Miller Scholarship, Institution of Civil Engineers. *Proceedings*, Vol. CII., p. 307.

ON THE PROTECTION OF BUILDINGS FROM LIGHTNING.*

BY A. R. BENNETT.

Considerable uncertainty is reputed to exist amongst architects and others who are occasionally called upon to erect lightning conductors. I have had quite recently two cases illustrative of this suspected uncertainty brought forcibly to my notice.

The first case occurred in connection with this present Exhibition. The Electrical and Lighting Committee decided that both the old and new systems of protection should be illustrated practically; so the chimney of the boiler-house was ordered to be protected by a stranded copper rope of the ordinary type, and the minarets of the main building by iron wire, according to a design kindly furnished by Dr. Oliver Lodge. The erection of the chimney proceeded with unexpected celerity, and when the Committee went to specify the precautions they wished to have observed in earthing the conductor they were informed that the conductor was up, earthed, and finished. The builder assured them that it was "all right;" but appreciating the ridiculous figure that would be cut by an Electrical Committee were a chimney under their special care struck and injured, it was resolved to do violence to the builder's feelings and dig up his earth. It was found that the end of the conductor was only a few inches below the surface, and was loosely embedded in builder's *débris*. This was the first case, and was detected and remedied in time. The second was only revealed by an actual visitation of lightning.

Last month, during a severe thunderstorm, and while it was raining very heavily, the inmates of a house were startled by a tremendous report. The house is peculiarly situated, being erected on the slope of a rocky hill, about 600ft. above the base and some 1,000ft. below the summit. It is fitted with the electric light, all the leads being within the building. A telephonic connection exists with the stables in the valley below, some 1,000 yards distant; it consists of two copper wires thickly insulated with gutta-percha, which are used as a metallic circuit. They are underground the whole way, being laid in a wooden box buried in a trench, except at one point, where they cross a stream in an iron pipe laid in its bed. When the flash occurred light

* Abstract of a Paper read at the Edinburgh International Exhibition on September 5, 1890, before the East of Scotland Engineering Association.

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was seen in almost every room of the house. A flame appeared around the kitchen grate. The housekeeper heard a faint rustling sound in the direction of one of the electric lamps, and was immediately conscious of a blaze of light, which seemed to dart from the lamp to the grate. A ball of fire, of a deep red colour, was seen, and a dazzling light of no defined shape appeared to play for an instant over the wall paper, which is embossed with metal. At the stables a ball of fire, of a white colour, about the size of a cricket ball, appeared in the middle of the room, and instantly exploded with a report. An examination showed that the safety fuses of the electric light system were melted. The hinged door of the box containing them, which was situated about 4ft. from the telephone on the same wall, was knocked off and thrown to a distance. It was much scorched inside. The telephone wires were fused in three different places, once in the iron pipe in the bed of the stream, once midway between the stream and the stables, and once a few yards on the house side of the stream. At the second place the wooden boxing was completely destroyed for about 6in.; at the third its bottom only was knocked out. In the stables the boxing was blown off the wall, but the wires escaped injury, as did the telephones at both ends. Where fused, the wires presented a sharpened or pointed appearance on the sections furthest from the house, and a rounded shape on those nearest it. At the moment of the discharge two bullocks grazing in the fields two or three miles off were struck dead. This tends to substantiate what has often been asserted, that lightning discharges frequently, if not invariably, are double; that at the moment a flash takes place from clouds to earth at one place, another ascends from earth to clouds at another, a phenomenon to which the name of back or return stroke has been given.

The house is largely roofed with lead, and has several iron spires which are in contact with the lead. The highest spire was found to be bulged and blackened at the junction of the iron with the lead. There are numerous metal drainpipes down the walls for carrying off the rain-water. These are in contact with the leadwork of the roof above; but no provision is made for earthing them below. When I add that there is no lightning-conductor, and that the house is built on a thin layer of soil covering rock, it will be seen that all the elements necessary for a first-class catastrophe were present. The absence of a conductor was accounted for by saying that when the house was built the architect stated that one was unnecessary. When telephone wires, and especially metallic circuits, are taken into a building they should be fitted as near the point of entry as possible with a good lightning discharge. This necessity I recognised several years ago as a consequence of more than one accident, since when all metallic circuits constructed by the National Telephone Company have been so fitted. Such a discharger, costing only a few pence, would in all probability have shunted the lightning to earth, and the inmates of the house might not have even been aware that a discharge had taken place. Telephones working with an earth return do not require such care as metallic circuits.

I recommend iron wire because, for the theoretical reasons adduced by Prof. Hughes and Dr. Oliver Lodge, iron is now widely admitted to be as effective as copper for currents appertaining to the character of lightning. When the greatest use has to be made of a certain sum I consider, theoretical reasons apart, that it is beyond comparison wiser to invest that sum in six or eight iron conductors than in one or two copper ones. Copper would be preferable on account of its greater durability when buried; but, still, galvanised iron will endure for years when so treated.

To secure immunity from lightning, certain invariable precautions have to be taken in all cases. These are specially, firstly, having at least one metal point—multiple points are much better—in as perfect connection with the earth as possible, preferably by several paths, raised above all stone, wood, and other non-conducting portions of the building. These points should be preferably over or quite close to the chimneys, unless wire cages are provided specially for them. Secondly, connecting all pipes, grates, bell-wires, and other masses of metal in the house to the conductors, preferably by means of soldered connections; when this cannot be managed, as with light and telephone leads, then by providing a small air space across which the discharge may jump harmlessly. Thirdly, by securing a good earth. When a house is built on rock, or on a thin stratum of soil over rock, or on chalk, this point requires special attention and study. Where gas and water pipes exist they should be joined to the conductors both above and below the ground, and gas and water meters should be bridged by soldered No. 5 wire. Even when water pipes exist Dr. Lodge considers it better to provide a separate earth for the conductor, also attaching it to the pipes; but this is a refinement I have not myself adopted when good water mains, always full, and jointed with lead, have been at hand.

In conclusion, I am able to show you some effects of a recent lightning storm, which emphasizes the necessity of having the highest point of any structure earthed. Last month a telephone wire erected on the tops of poles between Murtle and Cults in Aberdeenshire was struck. The wire was out of use, and was insulated at both ends, so that the lightning found no vent at the extremities. It accordingly struck through the solid porcelain insulators to the iron bolts supporting them, and jumped thence to the earth-wire, which was stapled up the poles to within an inch or two of the bolts. It shattered the insulators on the 1st, 2nd, 7th, 15th, and 35th poles, counting from Murtle. At three of the poles the wire, No. 18, B.W.G. silicium bronze, was fused, and at the foot of one pole the earth was disturbed and the grass burnt. Three of the insulators with fragments are on the table before you; the others were reduced entirely to small pieces, many of which could not be found. On one of those before you a metallic deposit from the fused wire is distinctly visible. Had each pole carried an earthed point raised above the topmost wire, the discharge would, almost to a certainty, have neglected the path of far higher resistance through the wire and porcelain, and all damage would have been avoided. This is a weak point in our telegraphic practice, common to Post Office, railway, and telephone companies, and one which I have raised my voice against for a good many years past. It is a curious question what the precise nature of the force is that splits porcelain in the manner shown. The destruction of trees and telegraph poles by lightning has been attributed to the sudden generation of steam in the pores of the wood due to the heat of the discharge or expansion by the heat of the air which the wood contains; but in porcelain there is neither moisture nor air, yet as you see, when it chances to intervene in the path of the least resistance, that does not prevent it from being split up and utterly destroyed.

THE LIGHT OF THE FIRE-FLY.

BY S. P. LANGLEY AND F. W. VERY.

In the *Philosophical Magazine* for September, the authors describe a research on "The Cheapest Form of Light," undertaken with the view of proving by actual measurement that the radiant energy emitted by the fire-fly is practically all utilised in producing luminous effect; and that the invisible heat rays which form so large and wasteful a proportion of the radiation emitted by all ordinary sources of light are, in this case, quite insignificant.

The chief results of the investigation are exhibited in the accompanying curves. In Fig. 1 a photometric comparison between

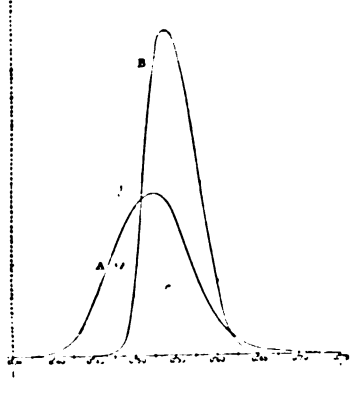

FIG. 1.

ordinary sunlight and the light of the fire-fly is exhibited by means of two curves, in each of which horizontal distances represent wave lengths, while ordinates denote luminous intensity as measured by a photometer. In the actual experiments the light of the sun was reduced until the total intensity of the rays tested was equal to that of the light given out by the fire-fly, before analysing either; and the curves have been so drawn as to have equal areas. It will be noted that while the maximum luminous intensity occurs in each curve in the neighbourhood of the yellow green rays the curve A for sunlight has a much broader base, and shows that the radiation of the sun is less confined to the rays, having the most intense luminous effect than is the case with the curve B, which represents fire-fly light. The four curves shown in Figs 2, 3, 4, and 5 are energy curves representing respectively the light emitted by the gas flame, the electric arc, the sun, and the fire-fly. In all these curves the abscissæ, or horizontal distances, represent wave lengths, as in Fig. 1; but the ordinates, instead of representing luminous intensity, denote the energy of the radiation of the particular kind represented by the corresponding abscissæ. The curves are drawn so that the area of each is the same. The

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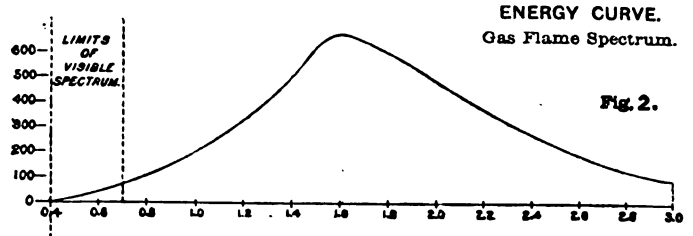
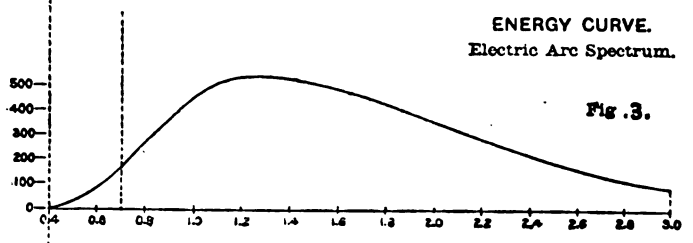
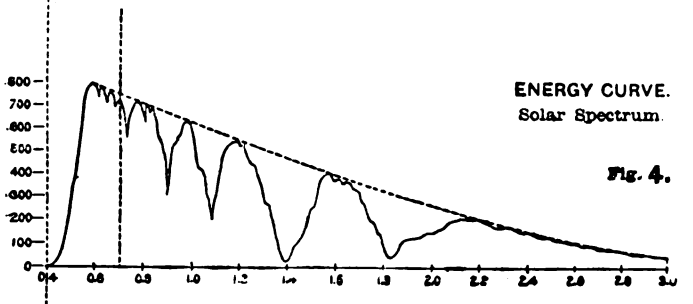
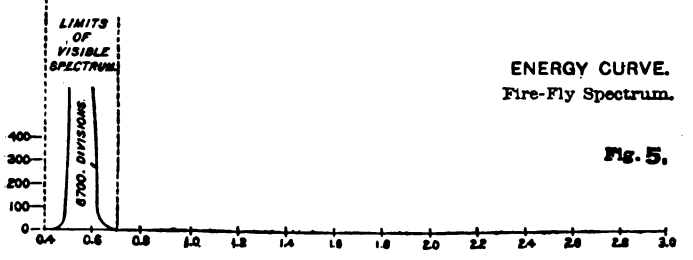
limits of the luminous spectrum are denoted by the dotted ordinates, and it is the area of the curve between these limits which represents the proportion of the energy actually used in producing luminous effect. The curve for the fire-fly is seen to lie entirely between these limits, and cannot be represented on the same scale owing to the magnitude of the ordinates; while the curve for the candle flame is such that only about one four-hundredth part of its area lies within the limits of the visible spectrum. If the light of the fire-fly could be manufactured on a large scale it would be far









cheaper than any other known form of light; and this does not appear impossible, since vital processes do not seem an essential feature in its production.

THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON.

(Continued from page 657.)

Let me show you yet another experiment. This is the same electro-magnet (Fig. 24) which has one flat pole and one rounded pole. Here is an armature, also bent, having one flat and one rounded pole. If I put flat to flat, and round to round, and pull at the middle, the flat to flat detaches first; but if we take round to flat, and flat to round, we shall probably find they are about equally good—it is hard to say which holds the stronger.

The law of traction can again be applied to test the so-called distribution of free magnetism on the surface: This is a subject on which I shall have to say a good deal. We must therefore carefully consider what is meant by the phrase. Let Fig. 26 be a rough drawing of an ordinary bar magnet. Every one knows that if we dip such a magnet into iron filings the small bits of iron stick on more especially at the ends, but not exclusively, and if you hold it under a piece of paper or cardboard, and sprinkle iron filings on the paper, you obtain curves like those shown on the diagram. They attest the distribution of the magnetic forces in the external space. The magnetism running internally through the body of the iron begins to leak out sideways, and finally all the rest leaks out in a great tuft at the end. These magnetic lines pass round to the other end, and there go in again, and the place where the steel is internally most highly magnetised is this place across the middle, where externally no iron filings at all stick to it. Now, we have to think of magnetism from the inside and not the outside. This magnetism extends in lines, coming up to the surface somewhere near the ends of the bar, and the filings stick on wherever the magnetism comes up to the surface. They do not stick on at the middle part of the bar, where the metal is really most completely permeated through and through

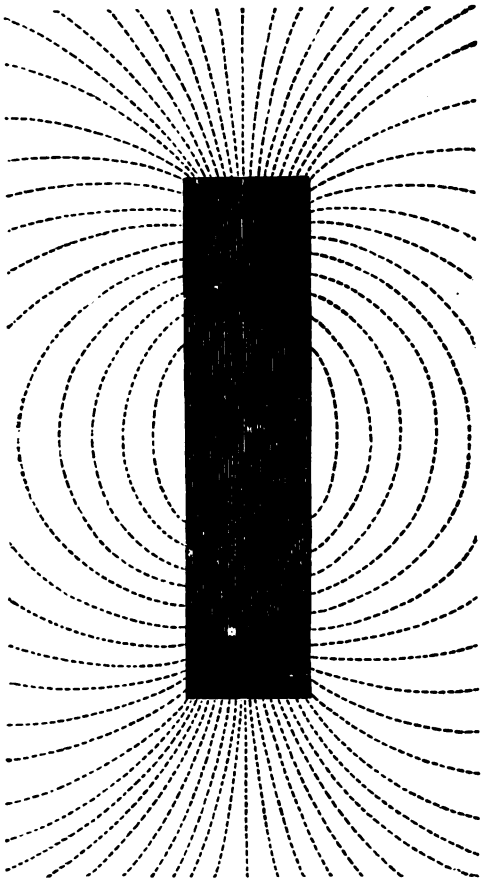


FIG. 26.—Lines of Force running through Bar Magnets.

by the magnetism; there are a larger number of lines per square centimetre of cross section in the middle region where none come up to the surface, and no filings stick on. Now, we may explore the leakage of magnetic lines at various points of the surface of the magnet by the method of traction. We can thereby arrive at a kind of measure of the amount of magnetism that is leaking, or, if you like to call it so, of the intensity of the "free magnetism" at the surface. I do not like to have to use these ancient terms, because they suggest the ancient notion that magnetism was a fluid or, rather, two fluids, one of which was plastered on at one end of the magnet, and the other at the other, just as you might put red paint or blue paint over the ends. I only use that term because it is already more or less familiar. Here is one of the ways of experimentally exploring the so-called distribution of free magnetism. The method was, I believe, originally due to Plücker; at any rate, it was much used by him. This little piece of apparatus was arranged by my friend and predecessor, Prof. Ayrton, for the purpose of teaching his students at the Finsbury College*. Here is a bar magnet of steel, marked in centimetres from end to end; over the top of it there is a little steel-yard, consisting of a weight sliding along an arm. At the end of that steel-yard there is suspended a small bullet of iron. If we bring that bullet into contact with the bar magnet anywhere near the end, and equilibrate the pull by sliding the counterpoise along the steel-yard arm, we shall obtain the definite pull required to detach that piece of iron. The pull will be proportional, by Maxwell's rule, to the square of the number of magnetic lines

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

* See Ayrton's *Practical Electricity*, Fig. 5a, p. 24.

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coming up from the bar into it. Shift the magnet on a whole centimetre, and attach the bullet a little further on; now equilibrate it, and we shall find it will require a rather smaller force to detach it. Try it again, at points along from the end to the middle. The greatest force required to detach it will be found at the extreme corner, and a little less a little way on, and so on, until we find at the middle the bullet does not stick on at all, simply because there are here no magnetic lines leaking. The method is not perfect, because it obviously depends on the magnetic properties of the little bullet, and whether much or little saturated with magnetism. Moreover, the presence of the bullet perturbs the very thing that is to be measured. Leakage into air is one thing; leakage into air perturbed by the presence of the little bullet of iron, which invites leakage into itself, is another thing. It is an imperfect experiment at the best, but a very instructive one. This method has been used again and again in various cases for exploring the apparent magnetism on the surface. I shall use it hereafter, reserving the right to interpret the result by the light of the law of traction.

I now pass to the consideration of the attraction of a magnet on a piece of iron at a distance. And here I come to a very delicate and complicated question. What is the law of force of a magnet—or electro-magnets—acting at a point some distance away from it? I have a very great controversy to wage against the common way of regarding this. The usual thing that is proper to say is that it all depends on the law of inverse squares. Now, the law of inverse squares is one of those detestable things needing to be abolished, which, although it may be true in abstract mathematics, is absolutely inapplicable with respect to electro-magnets. The only use, in fact, of the law of inverse squares, with respect to electro-magnetism, is to enable you to write an answer when you want to pass an academical examination, set by some fossil examiner, who learned it years ago at the University, and never tried an experiment in his life to see if it was applicable to an electro-magnet. In academical examinations they always expect you to give the law of inverse squares. What is the law of inverse squares? We had better understand what it is before we condemn it. It is a statement to the following effect—that the action of the magnet (or of the pole some people say), at a point at a distance away from it, varies inversely as the square of the distance from the pole. There is a certain action at one inch away. Double the distance; the square of that will be four, and, inversely, the action will be $\frac{1}{4}$; at double the distance the action is $\frac{1}{4}$; at three times the distance the action is $\frac{1}{9}$, and so on. You just try it with any electro-magnets; nay, take any magnet you like, and unless you hit upon the particular case, I believe you will find it to be universally untrue. Experiment does not prove it. Coulomb, who was supposed to establish the law of inverse squares by means of the torsion balance, was working with long thin needles of specially hard steel, carefully magnetised so that the only leakage of magnetism from the magnet might be as nearly as possible leakage in radiating tufts at the very ends. He practically had point-poles. When the only surface magnetism is at the end faces, the magnetic lines leak out like rays from a centre, in radial lines. Now the law of inverse squares is never true except for the action of points; it is a "point" law. If you could get an electro-magnet or a magnet, with poles so small in proportion to its length that you can consider the end face of it as the only place through which magnetic lines leak up into the air, and the ends themselves so small as to be relatively mere points; if, also, you can regard those end faces as something so far away from whatever they are going to act upon that the distance between them shall be large compared with their size, and the end itself so small as to be a point, then, and then only, is the law of inverse squares true. It is a law of the action of points. What do we find with electro-magnets? We are dealing with pieces of iron which are not infinitely long with respect to their cross section, and generally possessing round or square end faces of definite magnitude, which are quite close to the armature; and which are not so infinitely far away that you can consider the polar face a point as compared with its distance away from the object upon which it is to act. Moreover, with real electro-magnets there is always lateral leakage; the magnetic lines do not all emerge from the iron through the end face. Therefore, the law of inverse squares is not applicable to that case. What do we mean by a pole, in the first place? We must settle that before we can even begin to apply any law of inverse squares. When leakage occurs all over a great region, as shown in this diagram, every portion of the region is polar; the word polar simply means that you have a place somewhere on the surface of the magnet where filings will stick on; and if filings will stick on to a considerable way down toward the middle, all that region must be considered polar, though more strongly at some parts than at others. There are some cases where you can say that the polar distribution is such that the magnetism leaking through the surface acts as if there were a magnetic centre of gravity a little way down, not actually at the end; but cases where you can say there is such a distribution as to have a magnetic centre of gravity are strictly few. When Gauss had to make up his magnetic measurements of the earth, to describe the earth's magnetism, he found it absolutely impossible to assign any definite centre of gravity to the observed distribution of magnetism over the northern regions of the earth; that, indeed, there was not in this sense any definite magnetic pole to the earth at all. Nor is there to our magnets. There is a polar region, but not a pole; and if there is no centre of gravity of the surface magnetism that you can call a pole from which to measure distance, how about the law of inverse squares? Allow me to show you an apparatus (Fig. 27), the only one I ever heard of in which the law of inverse squares is true. Here is a very long thin magnet of steel, about 3ft. long, very carefully magnetised, so as to have no leakage until quite close up to the end. The consequence is that for practical purposes you may treat this as a magnet having point poles about an inch away from the ends. The south pole is upwards, and the north pole is below, resting in a groove in a base-board which is graduated with a scale, and is set in a direction east and west. I use a long magnet, and keep the south pole well away, so that it shall not perturb the action of the north pole, which being small, I ask to be allowed to consider as a point. I am going to consider this point as acting on a small compass needle suspended over a card under this glass case constituting a little magnetometer. If this were properly arranged in a room free from all other magnets, and set so that that needle shall point north, what will be the effect of having the north pole of the long magnet at some distance eastwards? It will repel the north end and attract the south, producing a certain deflection which we can read off; reckoning the force which causes it by calculating the tangent of the angle of the deflection. Now, let us move the north pole (regarded as a point) nearer or farther, and study the effect. Suppose we halve the distance from the pole to the indicating needle, the deflecting force at half the distance is four times as great; the force at double the distance is one quarter as great. Wherefore? Because, firstly, we have taken a case where the distance apart is very

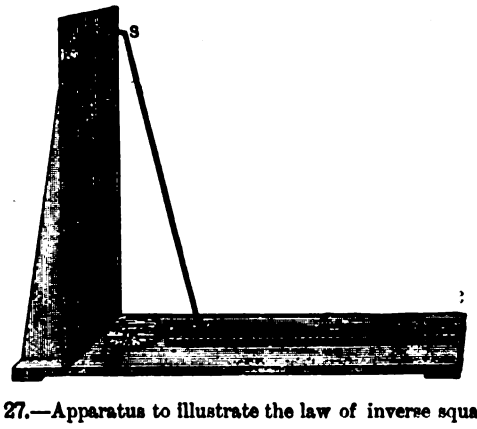

FIG. 27.—Apparatus to illustrate the law of inverse squares.

great, compared with the size of the pole; secondly, the pole is practically concentrated at a point; thirdly, there is only one pole acting; and, fourthly, this magnet is of hard steel, and its magnetism in no way depends on the thing it is acting on, but is constant. I have carefully made such arrangements that the other pole shall be in the axis of rotation, so that its action on the needle shall have no horizontal component. The apparatus is so arranged that whatever the position of that north pole, the south pole, which merely slides perpendicularly up and down on a guide, is vertically over the needle, and therefore does not tend to turn it round in any direction whatever. With this apparatus one can approximately verify the law of inverse squares. But this is not like any electro-magnet ever used for any useful purpose. You do not make electro-magnets long and thin, with point-poles a very large distance away from the place where they are to act; no, you use them with large surfaces close up to their armature.

There is yet another case which follows a law that is not a law of inverse squares. Suppose you take a bar magnet, not too long, and approach it broadside-on towards a small compass needle (Fig. 28). Of course, you know as soon as you get anywhere near the compass needle it turns round. Did you ever try whether the effect is inversely proportional to the square of the distance reckoned from the middle of the compass needle to the middle of the magnet? Do you think that the deflections will vary inversely with the squares of the distances? You will find they do not. When you place the bar-magnet like that, broadside-on to the needle, the deflections vary as the cube of the distance, not the square.

Now, in the case of an electro-magnet pulling at its armature at a distance, it is utterly impossible to state the law in that misleading way. The pull of the electro-magnet on its armature is not proportional to the distance, nor to the square of the distance, nor to the cube, nor to the fourth power, nor to the square-root, nor to

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the three-half root, nor to any other power of the distance whatever, direct or inverse, because you find, as a matter of fact, that as the distance alters, something else alters too. If your poles were always of the same strength, if they did not act on one another, if they were not affected by the distance in between, then some such law might be stated. If we could always say, as we used to say in the old language, "at that pole," or "at that point," there are to be considered so many "units of magnetism," and at that other place so many units, and those are going to act on one another; then you could, if you wished, calculate the force by the law of inverse squares. But that does not correspond to anything in fact, because the poles are not points, and further, the quantity of magnetism on them is not a fixed quantity. As soon as the iron armature is brought near the pole of the electro-magnet there is a mutual interaction; more magnetic lines flow out from the pole

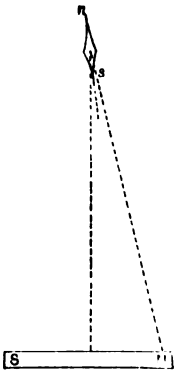

FIG. 28.—Deflection of needle caused by bar magnet broadside-on.

than before, because it is easier for magnetic lines to flow through iron than through air. Let us consider a little more narrowly that which happens when a layer of air is introduced into the magnetic circuit of an electro-magnet. Here we have (Fig. 29) a closed magnetic circuit, a ring of iron, uncut, such as that on which we experimented last week. The only reluctance in the path of the magnetic lines is that of the iron, and this reluctance we know to be small. Compare Fig. 29 with Fig. 30, which represents a divided ring with air gaps in between the severed ends. Now air is a less permeable medium for magnetic lines than iron is, or, in other words, it offers a greater magnetic reluctance. The magnetic permeability of iron varies, as we know, both with its quality and with a degree of magnetic saturation. Reference to Table III. shows that if the iron has

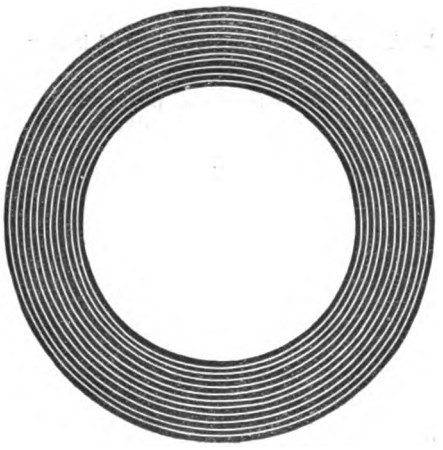

FIG. 29.—Closed magnetic circuit.

been magnetised up so as to carry 16,000 magnetic lines per square centimetre, the permeability at that stage is about 320. Iron at that stage conducts magnetic lines 320 times better than air does; or air offers 320 times as much reluctance to magnetic lines as iron (at that stage) does. So then the reluctance in the gaps to magnetisation is 320 times as great as it would have been if the gaps had been filled up with iron. Therefore, if you have the same magnetising coil with the same battery at work, the introduction of air-gaps into the magnetic circuit will, as a first effect, have the result of decreasing the number of magnetic lines that flow round the circuit. But, this first effect itself produces a second effect. There are fewer magnetic lines going through the iron. Consequently, if there were 16,000 lines per square centimetre before there will now be fewer—say only 12,000 or so. Now refer back to Table III., and you will find that when B is 12,000 the permeability of the iron is not 320 but 1,400 or so. That is to say, at this stage, when the magnetisation of the iron has been pushed only so far, the magnetic reluctance of air is 1,400 times greater than that of iron, so that there is a still greater relative throttling of the magnetic circuit by the reluctance so offered by the air-gaps.

Apply that to the case of an actual electro-magnet. Here is a diagram, Fig. 31, representing a horse shoe electro-magnet with an armature of equal section in contact with it. The actual electro-magnet for the experiment is here on the table. You can calculate

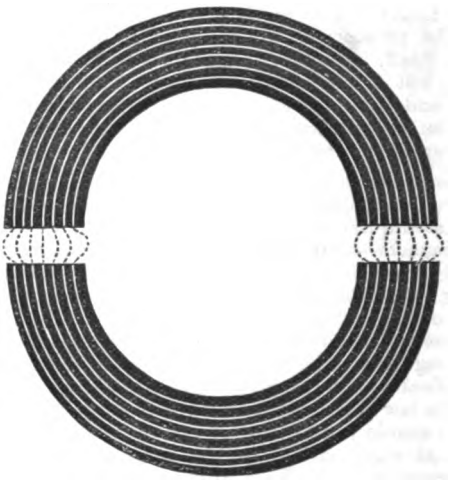

FIG. 30.—Divided magnetic circuit.

out from the section, the length of iron, and the table of permeability, how many ampere-turns of excitation will produce any required pull. But now consider that same electro-magnet, as in Fig. 32, with a small air-gap between the armature and the polar faces. The same circulation of current will not now give you as much magnetism as before, because you have interposed air gaps; and by the very fact of putting in reluctance there, the number of magnetic lines is reduced.

Try, if you like, to interpret this in the old way by the old notion of poles. The electro-magnet has two poles, and these excite in-

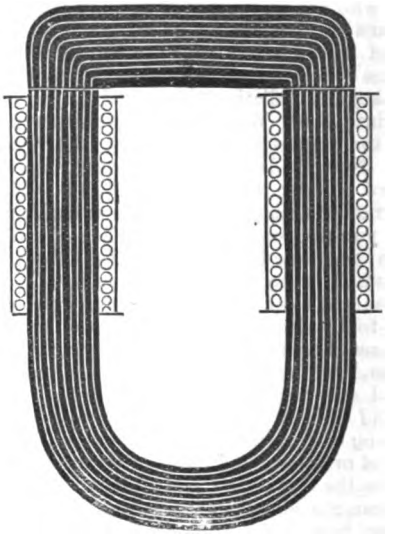

FIG. 31.—Electro-magnet with armature in contact.

duced poles in the opposite surface of the armature, resulting in attraction. If you double the distance from the pole to the iron, the magnetic force (always supposing the poles are mere points) will be one quarter, hence the induced pole on the armature will only be one quarter as strong. But the pole of the electro-magnet is itself weaker. How much weaker? The law of inverse squares does not give you the slightest clue to this all-important fact. If you cannot say how much weaker the primary pole is, neither can you say how much weaker the induced pole will be, for the latter depends upon the former. The law of inverse squares in a case like this is absolutely misleading.

Moreover, a third effect comes in. Not only do you cut down the magnetism by making an air-gap, but you have a new consideration to take into account. Because the magnetic lines, as they

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pass up through one of the air-gaps along the armature, down the air-gap, at the other end, encounter a considerable reluctance, the whole of the magnetic lines will not go that way ; a lot of them will take some shorter cut, although it may be all through air, and you will have some leakage across from limb to limb. I do not say you never have leakage under other circumstances ; even with an armature in apparent contact there is always a certain amount of sideway leakage. It depends on the goodness of the contact. And if you widen the air-gaps still further, you will have

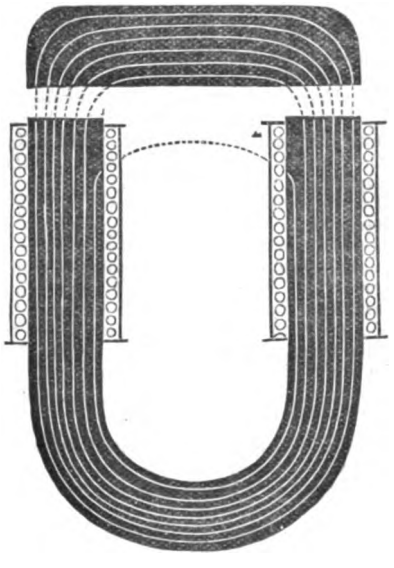

Fig. 32.—Electro-magnet with air-gaps one millimetre wide.

still more reluctance in the path, and still less magnetism, and still more leakage. Fig. 33 roughly indicates this further stage, The armature will be far less strongly pulled, because, in the first place, the increased reluctance strangles the flow of magnetic lines, so that there are fewer of them in the magnetic circuit ; and, in the second place, of this lesser number only a fraction reach the armature because of the increased leakage. When you take the armature entirely away the only magnetic lines that go through the

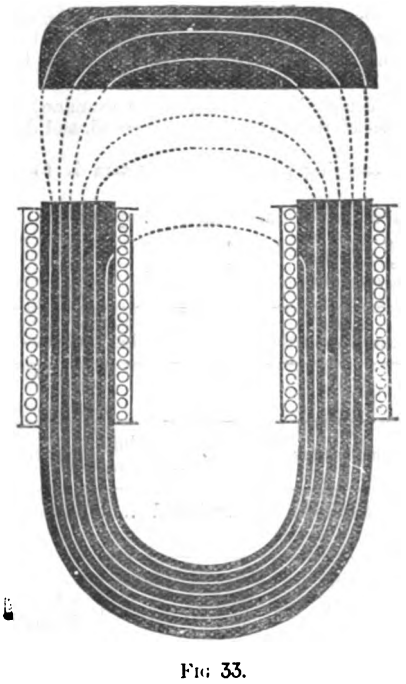

Fig 33.

iron are those that flow by leakage across the air from the one limb to the other. This is roughly illustrated by Fig. 34 the last of this set.

Leakage across from limb to limb is always a waste of the magnetic lines, so far as useful purposes are concerned. Therefore it is clear that, in order to study the effect of introducing the distance between the armature and the magnet, we have to take into account the leakage ; and to calculate the leakage is no easy matter. There are so many considerations that occur as to that which one has to take into account, that it is not easy to choose the right ones and leave the wrong ones. Calculations we must make by-and-by—they will be added as an appendix to this lecture—but for the moment experiment seems to be the best guide.

I will, therefore, refer, by way of illustrating this question of leakage, to some experiments made by Sturgeon. Sturgeon had a long tubular electro-magnet made of a piece of old musket barrel of iron wound with a coil ; he put a compass needle about a foot away, and observed the effect. He found the compass needle deflected about 23deg. ; then he got a rod of iron of equal length and put it in at the end, and found that putting it in so that only the end was introduced—in the manner I am now illustrating to you on the table—the deflection increased from 23deg. to 37deg. ; but when he pushed the iron right home into the gun barrel it went back to nearly 23deg. How do you account for that ? He had unconsciously increased its facility for leakage when he lengthened out the iron core. And when he pushed the rod right home into the barrel, the extra leakage which was due to the added surface could not and did not occur. There was additional cross-section ; but what of that ? The additional cross-section is practically of no account. You want to force the magnetism across some 20in. of air, which resists from 300 to 1,000 times as much as iron. What is the use of doubling the section of the iron ? You want to reduce the air reluctance, and you have not reduced the air by putting a core into the tube.

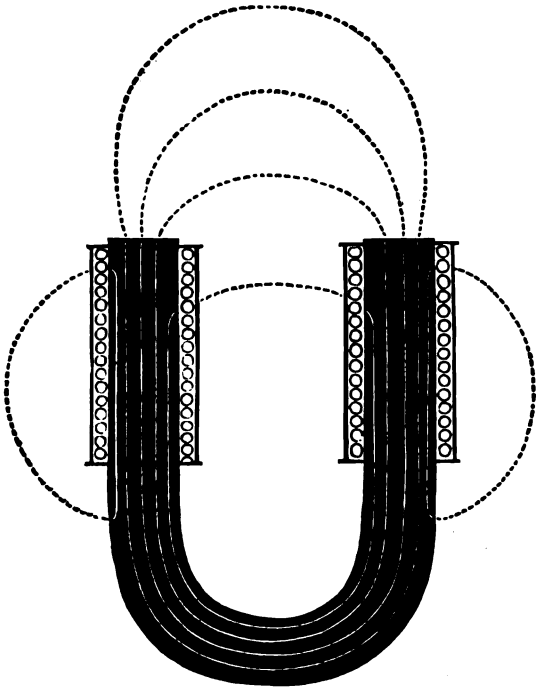

Fig. 34

There is a paradoxical experiment which we will try next week, that illustrates an important principle. If you take a tubular electro-magnet and put little pieces of iron into the ends of the iron tube that serves as core, and then magnetise it, the little pieces of iron will try to push themselves out. There is always a tendency to try and increase the completeness of the magnetic circuit ; the circuit tends to re-arrange itself so as to make it easier for the magnetic lines to go round.

Here is another paradoxical experiment. I have here a bar electro-magnet, which we will connect to the wires that bring the exciting current. In front of it, and at a distance from one end of the iron core, is a small compass needle with a feather attached to it as a visible indicator, so that when we turn on the current the electro-magnet will act on the needle, and you will see the feather turn round. It is acting there at a certain distance. The magnetising force is mainly spent not to drive magnetism round a circuit of iron, but to force it through the air, flowing from one end of the iron core out into the air, passing by the compass needle, and streaming round again, invisible, into the other end of the iron core. It ought to increase the flow if we can in any way aid the magnetic lines to flow through the air. How can I aid this flow ? By putting on something at the other end to help the magnetic lines to get back home. Here is a flat piece of iron. Putting it on here at the hinder end of the core ought to help the flow of magnetic lines. You see that the feather makes a rather larger excursion. Taking away the piece of iron diminishes the effect. So also in experiments on tractive power, it can be proved that the adding of a mass of iron at the far end

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of a straight electro-magnet greatly increases the pulling power at the end that you are working with; while, on the other hand, putting the same piece of iron on the front end as a pole-piece greatly diminishes the pull. Here, clamped to the table, is a bar electro-magnet excited by the current; and here is a small piece of iron attached to a spring balance, by means of which I can measure the pull required to detach it. With the current which I am employing the pull is about 2½lb. I now place upon the front end of the core this block of wrought iron; it is itself strongly held on; but the pull which it itself exerts on the small piece of iron is small. Less than half a pound suffices to detach it. I now remove the iron block from the front end of the core, and place it upon the hinder end. And now I find that the force required to detach the small piece of iron from the front end is about 3½lb., instead of 2½lb. The front end exerts a bigger pull when there is a mass of iron attached to the hinder end. Why? The whole iron core, including its front end, becomes more highly magnetised, because there is now a better way for the magnetic lines to emerge at the other end and come round to this. In short, we have diminished the magnetic reluctance of the air part of the magnetic circuit, and the flow of magnetic lines in the whole magnetic circuit is thereby improved. So it was also when the mass of iron was placed across the front end of the core; but the magnetic lines streamed away backwards from its edges; and few were left in front to act upon the small bit of iron. So the law of magnetic circuit action explains this anomalous behaviour. Facts like these have been well known for a long time to those who have studied electro-magnets. In Sturgeon's book there is a remark that bar-magnets pull better if they are armed with a mass of iron at the distant end, though Sturgeon did not see what we now know to be the explanation of it. The device of fastening a mass of iron to one end of an electro-magnet in order to increase the magnetic power of the other end was patented by Siemens in 1862.

(To be continued.)

REGULATIONS FOR THE ERECTION OF ELECTRIC WORK IN HANOVER.

A very elaborate set of regulations have been drawn up by the municipal authorities of the town of Hanover. On the recommendation of Prof. F. W. Kohlrausch, the Town Council voted 1,500,000 marks at the end of last year, for the erection of a 15,000 light central station. The Municipality are undertaking the laying of the mains on the three-wire system, the work being carried out by Messrs. Schuckert and Co. Contractors for wiring have to obtain a certificate from the Town Council, and these certificates, it appears, can only be obtained by those firms who have previously carried out electric light work in a satisfactory manner. These certificates are liable to be withdrawn, and the holders are liable for compensation to the town for any damage arising from work carried out in a faulty manner. Plans and samples have to be submitted before the work is commenced, and it has to be passed by a municipal inspector before connection may be made to the town mains.

After some general rules, which we have epitomised above, the following regulations are given:—

14. The general arrangement of conductors and all apparatus pertaining thereto is to be such that all parts of the installation are capable of easy inspection and access, and that in the event of any breakdown in working occurring it can be easily and quickly put right. The main conductors, with the switches requisite for the branch leads, and the safety cut-outs are to be in easily accessible places, and as far as possible grouped at chosen spots by the use of switchboards.

15. The system of interior wiring may be carried out on the simple two-wire system where the expected consumption does not exceed 1,500 watts (about 30 16 candle-power glow-lamps, or their equivalent).

Installations for an expected consumption of 1,500 to 3,000 watts (30 to 60 16 candle-power glow-lamps or their equivalent) are to be first divided into two as nearly equal as possible groups and equal sets of glow-lamps, not exceeding 10 in number (*see* § 21), are to be taken alternately from each group and connected on either side of a three-wire system, each half of which will always supply an approximately equal number of lights.

Installations for a consumption expected to exceed 3,000 watts are to be so arranged that the three-wire system is carried out in the house itself for all leads which supply more than 1,500 watts.

For each 3,000 watts such a system of leads is to be provided. The further distribution is to be so arranged that as nearly as possible equal numbers of lamps are supplied on each side of the system. In such three-wire systems the middle wire is to be of the same section as the two outside ones, except when this section exceeds 35 square millimetres, when the middle wire may be of the nearest smaller section. (*See* § 19).

When groups of more than ten glow lamps are placed together, and are all operated by the same switch (big crown lights, theatres, &c.,) the middle wire in the three-wire system may be omitted, so that two lamps are in series.

As to the necessary safety cut-outs *see* § 21.

16. The maximum allowable fall of potential in the leads from the meters to the place where any branch takes off is not to exceed 1·5 volts. No variation from this rule will be allowed except by express permission of the Municipal Electric Works.

In the case of arc lamps this test can be made at the lead fuse belonging to the lamp, from which point through the lamps, two or four in series, a fall of from 15 to 30 volts may occur. In arc lamps in the open this fall may occur in the conductor, which may be of galvanized iron.

17. The section of conductor necessary is to be calculated from the following:—

(*a*) For each incandescent lamp (mean voltage 107 volts) is to be laid a branch calculated on the basis of ·8 ampere. For incandescent lamps of over 32 normal candles the exact current strength necessary is to be considered.

(*b*) For each arc lamp a current of at least 10 amperes is to be taken; arc lamps requiring a larger current, however, have this taken into consideration.

(*c*) For electromotors and other applications of the current, the conductors are calculated on the basis of a current one and a half times its normal value. The capacity of fuses, switches, &c., is to be chosen accordingly.

The sections as calculated are always to be examined, to see that the allowable capabilities of the wires are not exceeded, and dangerous heating is avoided.

The maximum carrying power of conductors is to be reckoned as follows:—

For a section up to	4	square mm.	3	amperes per square mm.
,, ,,	6	,,	2·5	,, ,,
,, ,,	100	,,	2	,, ,,
,, ,,	over 100	,,	1·5	,, ,,

§ 18. The choice of conductors, insulation, and mode of fixing, is to be determined according to the following table:—

Description of Conductor.	Positions.					
	Under floors or cornices.	Open air.	Dry rooms.	Damp rooms.	Rooms containing gases or vapours.	Lighting apparatus.
Bare wire	Not allowed	Porcelain insulators.	Not allowed	Not allowed ..	Not allowed ...	Not allowed.
Insulated wire (flexible cords, I.-R. or G.P. covered wire.)	In ceilings or dry cornices, on porcelain insulators with wood casing, or in metal tubes (with free access for air).	Porcelain insulators.	Porcelain insulators or cleats, wood casing or cleats.	Porcelain insulators.	Porcelain insulators.	Loose inside tubes, which are secured by insulating bands or metal strips.
Plain lead cable ...	Not allowed	Porcelain cleats, wood cleats, metal cleats (with soft packing).	Wood casing, wood or metal cleats (with soft packing).	Not allowed ..	Not allowed ...	Not allowed.
Asphalted lead cable.	As for insulated wire ...	Wood or metal cleats.	Wood casing, wood or metal cleats.	Tinned metal cleats.	Not allowed ...	If necessary, as for insulated wires.
Iron-sheathed lead cable.	Without further precautions.	Wood or metal cleats.	Wood casing, wood or metal cleats.	Tinned metal cleats.	Not allowed ...	If necessary, as for insulated wires.

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Arrangement of Switches.

20. All switches, &c., employed must be so arranged that the conducting parts are surrounded by uninflammable materials well insulated from each other and from external objects. In particular all switchbases, &c., are to be uninflammable and of good insulating properties, especially in damp situations.

The switches shall be as far as possible brought together and fixed at suitable places on switchboards at such an elevation that they can be easily reached and attended to without the help of special appliances. In order to prevent their being meddled with, they are to be provided with covers.

In rooms in which combustible gases and vapours exist, or solid bodies in the shape of dust which form with air an explosive mixture, all switches are to be enclosed in perfectly air-tight casing; similarly also for rooms where corrosive fumes or gases arise. In such cases it is advisable to place all switches outside.

21. *Safety fuses.*—In the branch conductors, no more than 10 incandescent lamps may ever depend upon the same fuse.

The disposal of the lamps on the several branches must always be so effected that when more than five lamps are employed in one room, they are not all dependent on one and the same fuse. Fuses are to be so placed as to prevent every lamp, perhaps in more than one room, being extinguished through the melting of any one fuse.

The use of single pole cut-outs is not allowed. With two conductors, two pole cut-outs, and with three conductors three pole cut-outs are to be put up.

The two wire conductors branching from three wire systems (*see* § 15) are to be provided at the junction with movable cut-outs, so as to allow the branch to be connected on to either side of the three-wire system. These movable lead cut-outs are to be obtained from the Municipal Electric Works.

All fuse boxes are to be constructed so as to fit the lead fuses to be supplied by the Municipal Electric Works, and to be clearly marked with numbers corresponding with the numbers of the lead fuses.

The bases must be of fire-proof material of good insulating properties, even in damp rooms. The requisite cases are also to be made of fire-proof material. The construction of the cut-outs is to be such as to wholly obviate the possibility of their operating erroneously or in a dangerous manner. They shall operate as soon as a current twice as great as that allowed according to the capacity of the wire (*see* § 17) shall pass through the fuse.

The above rules hold good also for automatic mechanical safety cut-outs.

Mercury contacts will only be allowed by special permission of the Municipal Electric Works.

The design (which will be uniform) for the cut-outs to be used will be decided upon by the Municipal Electric Works, so that it shall be easily possible for their officials to inspect or otherwise attend to them.

22. Switches are to be placed on fireproof insulating bases, and to be covered with a fireproof casing, enclosing all parts through which the current passes. The making and breaking must always be the result of a springing action at both poles, and in all cases must be so constructed that the spring can only be at rest when it is at one end or the other of its play, *i.e.*—when the circuit is either closed or open. Where the three-wire system is in use, making and breaking is to be simultaneously effected at both external conductors.

Single-pole switches are only allowable in lamp fittings, and for single branches up to 10 incandescent lamps, and for arc light wires up to 10 amperes, which are connected to the leads by double-pole switches. It is to be noted that these single-pole switches are only to be used on one of the two external conductors, and never on the middle conductor of a three-wire system.

Rubbing contacts only may be used in which there is at least one square millimetre of contact surface for every tenth of an ampere.

In the case of switches with lever handle, the turning of the handle to the left or downwards is to open the circuit; turning it to the right or upwards is to close it, unless the switch is marked with special indications such as "closed," "open," or their equivalents.

Switches without handles are to be so arranged that it is possible to tell whether the circuit is open or closed without removing the cover.

Switches are to be conspicuously marked with the maximum current in amperes that they are allowed to carry.

In every installation a main switch for cutting off from the mains is to be provided close to the meter, and in an accessible position. If the conductors are divided into several branches behind the spot where they enter, each branch may be provided with a switch, and the main switch above referred to may be dispensed with.

In other respects the fixing of switches will depend upon circumstances. It is to be observed that it is only possible to extinguish all the lights by opening the main switch.

23. All resistances (rheostats) for arc lamps, &c., shall be so calculated that they shall reach at the highest a temperature of 50° C. Heating to a higher temperature, and especially to a red heat, is to be prevented. They must be well insulated and fastened to, and surrounded by fire-proof material. For such resistances iron, nickel, German silver, wire, &c., may be used, as well as copper.

24. Switchboards may best be placed at those spots on each floor of any installation where a large number of fuses, switches, resistances, &c., can readily be brought together in a place where they can be easily seen.

Switchboards, as well as the protecting cases belonging to them, are to be made of a non-combustible material, or of hard wood. All bright metal parts are to be covered, and interference on the part of incompetent persons is to be impossible.

The terminal strips on the switchboards, if of copper, must not carry more than 2 amperes; if of brass, not more than ½ ampere per square millimetre of section. Terminal strips lying next to one another must have a space of at least 3 centimetres between them. All crossing of the wires at the switchboards is to be avoided.

25. Meters are to be arranged and fixed exclusively by the Municipal Electric Works, and are to be hired by the consumers.

The sizes of the meters and the places where they are to be put are to be determined by the Municipal Electric Works.

The choice of a position will be made with due regard to its proximity to the street mains, and to the ease and convenience with which it may be got at without using stools, ladders, &c. Care will also be taken that bringing in the connecting cable shall present no particular difficulties, and that separate installations in the same house can be readily branched off when necessary.

If desired separate meters can be fitted to different parts of any installation.

Consumption of Current.

26. The choice of incandescent lamps is left to the consumers. It will, however, be to their advantage to obtain the lamps exclusively from the Municipal Electric Works.

For new installations only incandescent lamps with Edison filament, and for a normal mean tension of 107 volts will be allowed. For the connection of already existing installations further conditions are to be complied with.

The conductors of the lampholders must be insulated and fixed on to the lamp, and covered with a fireproof casing.

Suspending the lamp-holders directly on to the conductors is not allowed.

The use of glow lamps is permitted in all rooms; but where gases, vapours, or dust, that are inflammable, explosive or deleterious to metals, are produced (*see* § 20), the lamps must be enclosed in air-tight glass shades which also cover the connections between the lamps and the conductors.

27. The choice of arc lamps and the necessary carbons is also left to the consumers, but the Municipal Electric Works may express a decision on them and their applicability. It will, however, be advisable to obtain the lamps and the carbons from the Municipal Electric Works.

Arc lamps are to be supplied with wired globes provided with ash-holders to catch the droppings from the carbons. The globes must be securely attached to the lamp frames by means of clamps, and during the setting of the carbons must be suspended by chains, &c.

The lamps themselves are to be insulated as well as possible from their supports.

The use of the electric conductors for supporting the lamps is not allowable.

The lamps are to be brought into position by means of wire cords; letting down the lamps by incompetent persons is to be prevented.

The lamp attendants are to be particularly enjoined that the lamps are to be switched off before they are let down for the purpose of setting the carbons, regulating, &c.

The use of arc lamps in rooms in which explosive or easily inflammable gases and the like exist is absolutely forbidden.

28. The supply and erection of electro-motors* and their appurtenances is to be undertaken by the Municipal Electric Works or their agents.

29. The use of heating and cooking apparatus* is allowable, subject to the express permission of the Municipal Electric Works having been obtained.

With regard to laying, fixing, and insulating the conductors, &c., instructions are given that protecting casings are to be provided wherever the wires are liable to be meddled with or damaged, as, for instance, when they are placed within 2½ metres from the floor. Protecting tubes of vulcanite, china, or glass are to be used where wires are carried through walls, a separate tube being used for each wire, and no two tubes being placed within one centimetre of each other. In carrying conductors through flooring the protecting tubes are recommended to be placed inside gas-pipes, reaching at least 20 centimetres above the level of the floor. If for special reasons it is necessary to place wires inside walls or flooring, they have to be laid in channels of sheet iron at least two millimetres thick, and covered with slate or the like. For conveying wires through walls into the open air porcelain tubes with their mouths curved downwards are to be used. Soldered joints inside metal tubes are not allowed. In all cases it is to be observed that the air must have free access to the wires. Naked wires are only allowed in the open air at a height of not under 4 metres and not under 40 centimetres apart. They are to be supported on china insulators, and if long, to be protected by lightning conductors. They must not be brought within 1 metre of any telegraph or telephone wires. Where two wires cross they must either be held by a special fastening, so that they cannot approach within 2 centimetres of each

* Conductors for applying the current to commercial purposes must throughout their length be so marked that they cannot be mistaken for lighting conductors. Branching conductors for commercial purposes off the light leads, and *vice versâ*, is only allowable when special permission is granted.

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other, or one of the wires must be provided with an insulating sleeve of vulcanite, porcelain, or glass, or kept away from the other wire by an insulating collar. Similar regulations apply wherever a conductor crosses any metal-work. Conductors are to be connected together only by soldered joints, but they may be connected to apparatus also by binding screws. In the latter case it is recommended to make a loop at the end of the wire. The best way of removing the insulation of a wire—that is, by scraping and not by a circular cut at right angles to the wire—is also pointed out. Instructions are given that all soldering is to be done with resin, and that the joints are to be cleaned and insulated when cold. The methods to be adopted for securing the ends of stranded conductors are also pointed out.

When wood casing is used it is directed that the breadth of the bridge between the two grooves must not be under 1 centimetre. The wires are to be laid in the casing without the use of staples, and free access is to be allowed to the air. Paperhangings must not be laid over the wood-casing except in perfectly dry rooms. Cylindrical porcelain insulators also may only be used in dry or slightly damp rooms. They are to be so placed that the wires are not within 4 centimetres of each other, and the distance between the insulators must not exceed 75 centimetres. The wires must be at least 1 centimetre from the wall. In damp rooms and where steam exists, as well as in the open air, porcelain insulators of the telegraph pattern are to be employed. They are to be so placed that the wires if bare are 40 centimetres apart, and if covered 20 centimetres apart. Porcelain lamps are subject to regulations similar to those for cylindrical insulators. Metal clamps and staples must be tinned. They are to be used principally for lead-covered cables, and in special cases for fastening insulated wires to wooden walls in dry rooms. They must not be more than 40 centimetres apart, and must hold the wires at a distance of 2 centimetres from each other. All wood casings, insulators, &c., are to be fixed to the walls by means of wood screws. Where conductors are attached to any apparatus, the nearest point at which the conductors are fixed must not be more than 10 centimetres distant.

Various regulations follow, giving the Municipal Works the right to test the installations, and for that purpose to run all the lamps, &c., on any installation for two hours, at the cost of the undertakers.

The insulation resistance between a complete installation, including wires, apparatus, lamps, &c., and the earth must be for 1,000 m. length of conductors at least 60,000 ohms; the total insulation resistance of any installation, whatever its magnitude, must not fall below 30,000 ohms. The following table is to apply both for complete installations and for individual branches thereof:

Total length of wires laid.	Necessary insulation resistance to earth.
Under 200 m.	300,000 ohms.
200 to 300 m.	200,000 ,,
300 to 500 m.	100,000 ,,
500 to 750 m.	80,000 ,,
750 to 1,000 m.	60,000 ,,
1,000 to 1,500 m.	40,000 ,,
1,500 and over	30,000 ,,

The insulation resistance between two wires lying parallel to each other must be at least 100,000 ohms for 1,000 m. of conductor. The insulation resistance of any piece of apparatus or lamp, &c., must not be under 500,000 ohms. All apparatus before being connected is to be tested for insulation by the undertakers, or submitted to the Municipal Works for that purpose. Similar regulations apply to extensions to installations previously connected to the Municipal mains. The starting of an installation, *i.e.*, the putting in position of the lead fuses and the connection of the house-wires to the meter, is in all cases to be effected by the Municipal Electric Works. If any defect is found by the tests, the installation may be cut off from the mains at the cost of the undertakers until such defect is removed. A deposit of 1,000 marks is to be placed by undertakers in the hands of the Town Council; if on account of additions or improvements ordered by the Municipal Works this sum is reduced, the undertakers must make a fresh deposit to raise it again to its original value. The Municipal Works are entitled to charge the undertakers certain sums for inspection, testing, &c. These fees are for installations of

1 to	5	glow lamps (16 candle-power) or their equivalent ...	5	marks.
6 ,,	10	,,	... 10	,,
11 ,,	20	,,	... 15	,,
21 ,,	30	,,	... 20	,,
31 ,,	60	,,	... 30	,,
61 ,,	100	,,	... 40	,,
101 ,,	150	,,	... 60	,,
151 ,,	250	,,	... 80	,,
251 ,,	500	,,	...100	,,
500 & over		,,	...150	,,

These fees, if not paid within eight days, may be deducted from the sum deposited with the Town Council.

ON THE FORM OF SUBMARINE CABLES FOR LONG DISTANCE TELEPHONY.*

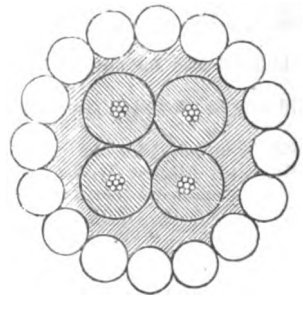
BY W. H. PREECE, F.R.S.

At the Newcastle meeting last year I gave the reasons and experiments which led to the conclusion that telephoning between London and Paris was practical. New and distinct aerial lines of four copper wires are now being erected by the respective Governments from each capital to the coast, and a new cable, the joint property of the two Governments, will be laid during this year, between the Kent coast and Sangatte, to connect these two lines. There will thus be two metallic circuits between the two capitals. The K R, that is the product of the capacity K, and the resistance R of each circuit, upon which the clearness of articulation depends, will be 5,900, indicating that speech should be excellent.

A somewhat similar circuit has been established, since October last, between Buenos Ayres and Monte Video, under my advice. The cables across the La Plata are each 28 miles long, for there are two separate single-wire cables, and the total distance between the two cities is 180 miles. Subscribers, who have metallic circuits in each city, have no difficulty whatever in speaking to each other from their respective offices, although the K R is as high as 10,400.

The cable across the Channel will be a four-wire cable, and the specification for its construction has been based on the following mathematical development by Mr. H. R. Kempe:—

The working capacity of the whole line is dependent upon the product of the total resistance, R, and the total capacity, K. Therefore, if we take the resistance of the aerial portion of the line to be a fixed quantity, there will be a particular size of cable conductor which will give the smallest possible size of dielectric, sufficient to enable a particular value of K R not to be exceeded. For, if we make the conductor larger than this size, and thereby diminish its resistance, we can, it is true, do with an increased



Section of the Telephonic Cable between England and France.

capacity; but the diminution in the thickness of the dielectric which could thereby be allowed, is more than compensated for by the fact that the surface of the conductor is larger; in other words, we increase the capacity in a greater proportion than we diminish the resistance. If, on the other hand, we diminish the size of the conductor, we increase the resistance in a greater proportion than we diminish the capacity. Strictly speaking, the requirements of the problem are to determine the size of cable core which shall *cost least*; but inasmuch as the costs of gutta-percha and copper, *bulk for bulk*, do not differ greatly, the problem resolves itself into the determination of the smallest outer diameter which can be employed.

Let r = total resistance of aerial line,
ρ = ,, ,, cable,
k = ,, capacity of aerial line,
κ = ,, ,, cable.

Then $$K R = (k+\kappa)(r+\rho).$$

Let D = diameter of dielectric of cable,
x = ,, conductor ,,

Then $$\rho = \frac{a}{x^2} \text{ and } \kappa = \frac{b}{\log_\epsilon \frac{D}{x}}$$

where a and b are constants.

We have, therefore,

$$K R = \left(k + \frac{b}{\log_\epsilon \frac{D}{x}}\right)\left(r + \frac{a}{x^2}\right).$$

* Abstract of Paper read before the British Association, Section G, Leeds, September, 1890.

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Therefore

$$\log_\epsilon \frac{D}{x} = \frac{b\left(r + \frac{a}{x^2}\right)}{KR - k\left(r + \frac{a}{x^2}\right)}.$$

Therefore,

$$\log_\epsilon D = \frac{A + \frac{1}{x^2}}{B - \frac{C}{x^2}} + \log_\epsilon x = u, \text{ say,}$$

where

$$A = \frac{r}{a} \qquad B = \frac{KR - kr}{ab} \qquad C = \frac{k}{b}.$$

Now to make D a minimum we must make $\log_\epsilon D$ (that is, u) a minimum, and this we have to do by variation of x, therefore we have

$$\frac{du}{dx} = \frac{1}{\left(B - \frac{C}{x^2}\right)^2}\left\{\left(B - \frac{C}{x^2}\right)\frac{2}{x^3} - \left(A + \frac{1}{x^2}\right)\frac{2C}{x^3}\right\} + \frac{1}{x} = 0.$$

Therefore,

$$x^2 - x\frac{\sqrt{2(B + AC)}}{B} = \frac{C}{B}.$$

From which, by solving the quadratic equation, we get

$$x = \frac{\sqrt{B + AC} + \sqrt{B + AC + 2BC}}{\sqrt{2B}}.$$

Now, careful experiments made on aerial line of copper wire, weighing 200lb. per mile (diameter = 112 mils.), the wire being 30ft. above the ground, showed that the inductive capacity per mile was ·015 microfarads very nearly, consequently the capacity per mile is expressed by the formula ·061637/6·1583625 − log d, d being the diameter of the wire in mils. From this formula the capacity per mile of a wire weighing 400lb. works out ·0156 m.f. The average resistance per mile of this weight is 2·25 ohms.

Taking the distance between London and Dover to be 70 miles, and between Calais and Paris to be 180 miles, the total distance of the loop will be 500 miles, which for a 400lb. copper wire gives the resistance $r = 500 \times 2{\cdot}25 = 1{\cdot}125$ ohms.

Now, in the case of a looped wire, the total capacity equals half that of a single wire, hence $k = {\cdot}0156 \times 250/2 = 1{\cdot}95$.

Assuming the length of thecable to be 21 knots, we have approximately $\rho = 42 \times 74{,}402/x^2$ for copper of 98 per cent. conductivity at 60° F, so that $a = 3{,}124{,}884$.

The ordinary standard core used by the Post Office has a conductor diameter of 86·41 mils., and a gutta-percha diameter of 285 mils., and a capacity of 1/3 m.f. per knot, and as capacity per knot = const./ $\log \frac{D}{d}$, we have

$$\text{const.} = \frac{\log \frac{285}{82{\cdot}087}}{3} = {\cdot}18018997.$$

The capacity of 42 knots of looped cable will be half that of 21 knots of single cable, hence

$$\kappa = \frac{{\cdot}18018997 \times \frac{21}{2}}{\log \frac{D}{x}}.$$

so that $b = 4{\cdot}356481$.

We have then for 400lb. wire $a = 3{,}124{,}884$, $b = 4{\cdot}356481$, $r = 1{,}125$, $k = 1{\cdot}95$.

If we take K R = 7,500, which is the highest value that can safely be taken, we get B = ·000389779; A C = ·0001611454, so that $x = 97{\cdot}00014$ and extreme diameter of strand = 102·1054 mils. Since $KR = (k + \kappa)(r + \rho)$ we get $\kappa = 3{\cdot}197153$.

But

$$\kappa = \frac{1{\cdot}89199468}{\log \frac{D}{x}}$$

Therefore log D = 380 mils approximately.

If we take

$x = 95$	then	D = 378·94
,, 97·00014	,,	,, 378·86
,, 99	,,	,, 379·08

which proves the correctness of the calculation for a minimum.

The values of these diameters correspond very closely to a core, the weight of whose conductor is 160lb., and the weight of whose gutta-percha covering is 300lb., and it has therefore been decided to adopt these dimensions.

Although the calculation has been made on the assumption that the land lines on both sides of the cable are to be of 400lb. wire, the French Government have decided that the wires to be erected by them shall be of 600lb. weight; the result of this will be to reduce the value of K R to 5,900, as stated at the commencement of the Paper.

The specification of the cable states that:—(1) Each conductor shall be formed of a strand of seven copper wires all of equal diameter, shall weigh 160lb. per nautical mile, and shall at a temperature of 75° Fahrenheit have a resistance not higher than 7·632 ohms, or lower than 7·478 ohms per nautical mile.

(2) Each conductor shall be insulated by being covered with three alternate layers of Chatterton's compound and gutta-percha, beginning with a layer of the said compound, and no more compound shall be used than may be necessary to secure adhesion between the conductor and the layers of gutta-percha. The dielectric on each conductor shall weigh 300lb. per nautical mile, making the total weight of each conductor when covered with the dielectric 460lb. per nautical mile.

(3) The inductive capacity of such insulated conductor shall not exceed ·3045 microfarad per nautical mile.

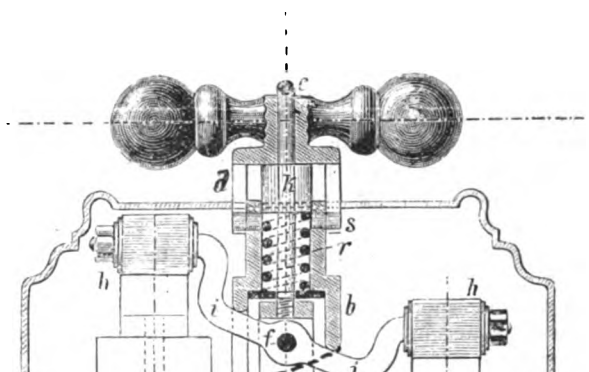
(4) The insulation resistance of such coil of core shall be not less than 500 megohms per nautical mile after such coil shall have been kept in water maintained at a temperature of 75° Fahrenheit for not less than 24 consecutive hours immediately preceding the test, and after electrification during one minute.

The cores (four in number) are to be served with the best wet fully tanned yarn, and with a sheathing of 16—280 mil. wires, each having a minimum breaking strain of 3,500lb., and a minimum of 10 twists in 6in. The section of the cable is shown by the figure.

THE MARCHER SWITCH.

A new switch that is being brought out by Herr Th. Marcher, of Neumarkt, near Nuremburg, appears to satisfy some of the more important conditions for this class of apparatus.

As may be seen from the figure, which shows a section through the centre, this switch (which is of the two-pole class) consists of a lever i, carrying the contact surfaces h, and working on the pin f. A hollow cylinder b, cut off helically at the base, is pressed down on to the lever by means of a spring r, which bears against the collar k on the fixed pin c. A second hollow cylinder, turning with the switch handle, is slotted at d, and rests on k. The slot d carries the pin s, which is fixed to the hollow cylinder b. The contacts h are insulated from the lever i.



Section of the Marcher Switch.

It will be clear that on turning the handle, so that the left-hand side moves downwards, the helical edge of the hollow cylinder b will slide over the arms of the lever i, the spring r thereby being compressed. As the pressures on both arms of the lever are equal, the contact is not disturbed until a half-turn is accomplished. The end of the helix has then arrived at the right-hand arm of the lever i, which is consequently suddenly released from all pressure on that side. The spring r then forces the cylinder b downwards, and the contact is instantly broken. Another half-turn causes the same action on the other side of the lever, and the circuit is suddenly closed again.

The only drawback to this ingenious arrangement is the nature of the contacts, which are solid brass wedges, forced between compact bundles of sheet copper. There is little, if any, sliding which is indispensable to a switch large or small.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 3, 1890.

Electric Traction.—Comparatively little new is occurring in electric circles just now. There is the usual crop of inventions of a more or less trivial character, and occasionally something more notable. A new supply system for street railways has just been patented, which is of some interest, albeit its merit is a matter for future experiment. It is of the same general character as the Pollock and Binswanger, Wheless, and several other recent tramways. The principal characteristic of this latest comer is an exceedingly ingenious system of cross wiring between consecutive sections, so that when a single one of the switches connecting a working conductor with a supply conductor is closed the operation will go on automatically as the car moves along without the necessity of carrying a battery on the car, or using any purely mechanical means of operating the successive switches. The Wheless is the only system of this character that has been given anything like a trial on this side of the Atlantic. There is a short experimental Wheless road in Washington, D.C., which operates fairly well, although it is not extensive enough to enable one to draw very sweeping conclusions as to its practicability on a commercial scale.

Electric Motors for Gunnery Purposes.—A novel use for the electric motor was shown a few days ago in the fitting of a Gatling gun, intended for use in the United States Navy, with a small motor to replace the crank by which that instrument of warfare is generally operated. The motor was supported by a bracket at the rear of the gun, and worked the breech mechanism through the medium of current. After the gun was thus fitted it was placed on one of the Government tugs and given a careful trial by the naval authorities. The result was highly satisfactory. A speed of firing as high as 1,000 shots per minute was attained without the least trouble, and the motor was so thoroughly controllable that single shots could be fired as readily as the gun could be operated at full speed. The officers present were much pleased with the results of the test, and it is not at all improbable that more weapons will be similarly fitted. In the same line is the electrical training of heavy guns. One of the new 8in. rifled guns is now being fitted with electrical training and elevating gear. Such an application, of course, is not novel, but it is new in the United States Navy, and all the improvements of former practice will probably be introduced into the present arrangements.

A Telephonic Central Station.—An attempt will, it is said, soon be made to organise a sort of telephonic concert company for furnishing music from a central station to regular subscribers at stated intervals. Experiments have been made on the details of telephones for reproducing music, and it may be that the plan will be carried through. Those who have it in hand seem to be quite in earnest about it, and say that a considerable number of subscribers can be obtained at once. At present, however, the telephone does not reproduce music with the fidelity that would be desirable if it were to be used on so large a scale.

CORRESPONDENCE.

MEASURING THE INSULATION RESISTANCE OF ELECTRIC LIGHT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With regard to the method M. Boucherot suggests for the measurement of the insulation resistance of electric light circuits (*Electrician*, September 26, 1890), the idea of using the voltmeter in the manner described occurred to me, as an improvement on the dodge of putting lamps between the leads and earth, some time in 1887; and I have used it almost continuously since as a check on the insulation of the ship installations with which I have had to do.

The instrument is joined up so that it may be readily switched between the leads to measure the total voltage, or between one or other lead and earth, to measure the apparent voltage through the fault in the *opposite* lead—the ratio of the difference in these readings to the last giving the resistance of the fault in terms of the voltmeter resistance.

The arrangement is of great convenience, in so far as it enables the attendant to make sure that the circuits are free from serious leakage several times during the night; but I doubt with you that it would be very useful as a mode of obtaining reliable quantitative insulation tests, with an ordinary voltmeter, except in cases of rather long circuits.—Yours, &c.,

WALTER J. MURPHY,
Electrician in charge, Eastern Telegraph Co.'s C.S. Electra.
Malta, October 4, 1890.

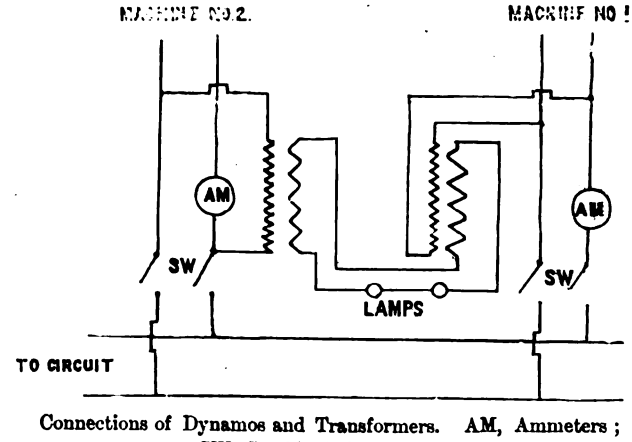
RUNNING ALTERNATORS PARALLEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may interest your readers to know that during the past few days we have tried running the Mordey Alternators here in parallel. The results have been in every way satisfactory.

As we had no synchroniser, we joined a transformer to each of the two machines, and put the secondaries in series with two incandescent lamps, so that when the two machines were in phase, the lamps were bright, as with an ordinary synchroniser. We tested the transformers for this by so connecting them both on to one machine that the two lamps in series were bright with the secondaries in series. We then transferred the primary wires of one transformer so as to connect it to the corresponding poles of the other machine.

We send you a sketch of the connections. From these you will see that any current passing from one machine to the other is registered on both the ammeters.



Connections of Dynamos and Transformers. AM, Ammeters; SW, Double Pole Switches.

The machines were first put parallel when the load on the one supplying current to the outside circuits was only five amperes. They went into step at once and kept so. The current going between the machines to keep them in phase was not sufficient to make the needles swing more than two ampere divisions on the ammeters. The load was transferred to either machine quite easily by speeding its engine up slightly by means of its governor.

The second dynamo was switched out of and into the circuit several times as the load went up. They were then run parallel till after the heavy load of the evening (about 40 amperes) was passed, each machine taking half.

During the heavier loads the swing of the needles was greater, showing that more current was being sent between the machines, but this would correspond to only three or four amperes.

When the load dropped under 30 amperes, the load was transferred to one dynamo, and the other switched out of circuit.

We have also made the experiment of switching them in parallel when not at the same voltage. The difference was about 3 per cent. The current which flowed between them was 10 amperes. This seems to indicate that a very large current indeed must have passed when Mr. Mordey made his experiment of putting a machine at 1,000 volts in parallel with one at 2,000 volts.—Yours, &c.,

Bath, October 15, 1890. GEO. S. HOOKER, Electrician.

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TRADE NOTES AND NOTICES.

HELSBY TELEGRAPH WORKS.—We are informed by the Telegraph Manufacturing Company that a circular which has been issued by Mr. Slater Lewis, who, some eighteen months ago, resigned his position with them, is calculated to injure and annoy them. They inform us that the works mentioned by him as the original telegraph works at Helsby consisted of a wooden shed, and that he he did not commence to do any manufacturing until 1883.

TENDERS WANTED.—The Southend Volunteer Fire Brigade invite tenders for fitting up electric call bells and wires. Further particulars are given in our advertising columns, and full details of the work required may be obtained of Captain Baker, High-street, Southend-on-Sea. Tenders have to be in not later than the 27th inst.

SALE BY AUCTION.—Messrs. Wheatley Kirk, Price and Goulty announce the sale at an early date of the high-class and nearly new electrical plant used for a short period by the Westminster Electric Supply Corporation for lighting the House of Commons. The catalogue will shortly be ready, and will include a number of Goolden alternating-current and compound and shunt-wound dynamos, a pair of 16 horse-power compound horizontal engines by Marshall, shafting, motors, transformers, belting, instruments, pumps, &c. Further particulars will be found in our advertising columns.

SALE BY TENDER.—Mr. Charles Lee Nichols, the official liquidator of the Pontypridd and Rhonda Valley Tramways Co. (Limited), and the receiver and manager of its undertaking, offers for sale by public tender the undertaking of the Company, consisting of 3 miles 102 yards, or thereabouts, of single line complete, constructed and now working under an order of the Board of Trade confirmed by the Tramways Order Confirmation Act (No. 2) 1882. The special advantages claimed for this Company's system of tramways will highly commend it to the notice of electrical traction companies, the districts through which it runs, possessing, as they do, a large travelling population, necessitating a frequent service, and facilities of a most unusual character for the generation of electrical power by water or steam can be obtained along the whole length of the line. From a report dated March 31st, 1890, made by a well-known tramway engineer on this line, it is stated that the present net earning capacity of the line, properly managed, would be £1,200 per annum, which is equal to a £5 per cent. per annum dividend on a capital of £24,000. Tenders must be sent in to Charles Lee Nichols, 1, Queen Victoria-street, London, E.C., marked "Pontypridd Tramways Tender," on or before Saturday, the 25th inst., and tenders will be opened at 11 o'clock on the following Monday. Full particulars, with conditions and forms of tender, may be obtained of Messrs. Stevens, Bawhee, and Stevens, 73A, Queen Victoria-street, London, E.C.; and of C. L. Nichols, Esq., 1, Queen Victoria-street, London, E.C.; or of Messrs. Iliffe, Henley, and Sweet, 2, Bedford-row, London, W.C. Further details are given in our advertisement columns.

THE LEVER ARC LIGHT.—Our advertisement columns contain an announcement that the British and foreign patent rights and the stock of lamps and apparatus of the Lever light (invented by the late Mr. Charles Lever) are for sale. Particulars and all further information can be obtained of Messrs. Dendy and Pearson, solicitors, 5, Cross-street, Manchester.

THE ARCHER PIPE COMPANY.—This Company are offering their patent jointed stoneware pipes for carrying electric conductors. The joint consists of a double spigot, and is run solid with cement through holes provided for the purpose. A length of 4-in. pipes was put under a head of 13ft. of water by the jury at the Edinburgh Exhibition, and was found to be watertight. To test their bridging power, three 4in. Archer pipes, each 2ft. long, were supported at the ends and weighted at the centre, and broke at about 5cwt., the joints remaining intact. We are informed that these pipes can be delivered in London and laid at 1s. 1d. per yard run. These pipes are being both laid in the ground, and in concrete for conveying electric wires.

MESSRS. PRIESTMAN BROTHERS (LIMITED).—This firm have been awarded a gold medal for the oil engine exhibited by them at the Edinburgh Exhibition.

"RULES FOR CONCENTRIC WIRING," BY J. D. F. ANDREWS.—This pamphlet consists of a number of rules drawn up by the inventor of this ingenious system of wiring. Since we are not aware that anyone else employs the method, it appears that these regulations will apply only to himself. The pamphlet is, however, not so useless as might be imagined, for it indirectly describes the system, which has been most carefully worked out in many details.

PYROSTAT COMPOSITION.—This non-conducting composition received the silver medal at the Edinburgh Exhibition, where the main steam pipes were protected by it. Messrs. Haache and Co., whose fossil meal composition is well known, have made use of asbestos instead of vegetable fibre, and thus the composition can be applied to even red-hot surfaces.

SAXONIAN BRONZE WARE.—Messrs. Berend and Co., the representatives in this country of the Saxonian Bronze Ware Manufactory, have just received some elegant examples of electric light fittings, all of which display great taste in design. There are eight specimens in all on the sheet of plates before us, and special mention should be made of Nos. 2,385, 2,387, 2,389, 2,390, and 2,391.

MESSRS. PATERSON AND COOPER.—This firm have opened a West-end showroom at 3, Prince's Mansions, Victoria-street, S.W., where samples of their manufactures will be kept.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

September 25, 1890.

15,249. A. MUIRHEAD. London. Improvements in the manufacture of electrical conductors.

15,250. H. SOUTH. London. Improvements in and relating to the electric circuit connections used for lighting theatres, and for analogous purposes.

15,251. H. SOUTH. London. An improved supporting base for electric lamps, and conduits for conductors therefor.

15,252. H. SOUTH. London. An improved holder for incandescent electric lamps.

15,262. W. H. WENNAL. London. Improvements in electrical drop-indicators.

15,274. E. B. BRIGHT and F. W. ENGELBACH. London. A method of, and appliances for automatically utilising any excess of electricity generated for electric lighting and other purposes, and for automatically supplying any deficiency.

15,283. E. THOMSON. London. Improved means of ascertaining immediately whether exit-doors or entrances of theatres and other public buildings are unfastened or not.

September 27, 1890.

15,293. A. W. RICHARDSON and H. A. HADWEN. Manchester. Improvements in arc lamps.

15,318. W. F. C. WARD and J. HALL. London. An improved cut-out.

15,328. C. ZIPRONOWSKI. London. Method and devices for heating by means of electric currents.

15,337. J. B. N. BONNARDOT. Liverpool. Improvements in or relating to electric alarm bells.

September 29, 1890.

15,401. A. L. SAX and C. W. SAX. London. Improvements in electrical switches.

15,413. T. B. GRANT. London. An arc electric lamp.

September 30, 1890.

15,442. C. E. MCCLUER. London. An artificial ground and compound metallic circuit system.

15,455. W. P. THOMPSON. Liverpool. Improvements in or appertaining to welding metals electrically (C. L. Coffin, United States).

15,456. W. P. THOMPSON. Liverpool. Improvements in or appertaining to welding metals electrically (C. L. Coffin, United States).

15,464. T. SULLIVAN, J. W. HUGHES, V. W. CHEMERY, and A. H. and D. S. BROWNE. London. Apparatus for governing electric-light engines, marine engines, and other engines.

15,469. O. IMRAY. London. Improved method of and apparatus for administering electricity to the human body (the Bethel Electric Medical Baths Company, Limited, Australia).

15,482. H. H. LAKE. London. Improvements in and relating to electric batteries (Crosby Electric Company, United States).

October 1, 1890.

15,536. A. T. COLLIER. Caterham Valley, Surrey. Improvements in telephone receivers, usable also as transmitters.

15,547. J. A. ILIFFE and F. TEAGUE. London. Improvements in locked switches for electric current circuits.

October 2, 1890.

15,573. F. J. DOWN. London. An improved method and means of attaching and suspending electric and other fittings.

15,629. W. WHEATLEY and J. LEWIS. London. Improvements in telephone transmitters and induction coils to be used therewith, and for other purposes.

15,634. J. WETTER. London. Improvements in instruments for measuring electric energy (A. M. B. de Montessus de Balloze, France).

16,635. C. J. HALL. London. Improvements in or relating to the method and means employed for commuting alternating currents of electricity, and distributing or storing the electrical energy so obtained.

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15,640. E. HANCOCK and A. J. MARQUAND. London. Improvements in electric or secondary batteries.
15,643. E. HOPKINSON. London. Improvements in and connected with electric tramways or railways, and for working electrically propelled vehicles thereon.
15,644. W. BROWN. London. Improvements in electric clock-circuit-closing apparatus.

October 3, 1890.

15,654. C. W. COX and F. ROBINSON. Liverpool. Improvements in pull-down switches for walls or ceilings for electric light.
15,673. H. T. O. FRASES. London. Improvements in telephonic switching and signalling apparatus.

October 4, 1890.

15,741. T. R. DOUSE. London. Electric fire indicator.

October 6, 1890.

15,774. A. FRIS. London. Electric advertising balloon.
15,777. B. J. B. MILLS. London. Improvements in electric meters (T. Blein, France).
15,792. B. J. B. MILLS. London. Improvements in incandescent electric lamps, and leading-in wires therefor (T. A. Edison, United States).

October 7, 1890.

15,819. J. JOHNSTONE. Edinburgh. Improvements in electric dynamos, electric motors, transformers of electric currents, and induction coils.
15,828. W. F. KING. Glasgow. Improvements in dynamo machines.
15,869. C. R. BONNÉ. London. Improvements in multiple switch boards (Mix and Genest, Limited, Germany).
15,871. C. R. BONNÉ. London. Improvements in multiple switch boards (Mix and Genest, Limited, Germany).
15,873. C. R. BONNÉ. London. Improvements in multiple switch boards (Mix and Genest, Limited, Germany).
15,890. R. DICK. London. Improvements in automatic electrical firing apparatus for naval and military ordnance.

October 8, 1890.

15,921. R. DICK and J. D. MACLEAN. Glasgow. Improvements in and relating to incandescent electric lamps.
15,933. S. E. KELF and E. HENNER. Reading. Actuating photographic camera shutters by electro-magnetic and electro-voltaic means.
15,974. H. S. HEATH. Leyton. Improvements in coin-feed apparatus for administering electricity.

October 9, 1890.

16,005. W. J. S. BARBER-STARKEY. Manchester. Improvements in separators for galvanic batteries.
16,031. J. TREEZIOK. London. Improvements in the process of manufacturing composition insulators for electrical purposes, applicable also to other articles made of fire-resisting composition.
16,054. H. G. C. SERRIN. London. Improvements in electric batteries.
16,055. H. G. C. SERRIN. London. Improvements in electric batteries.
16,057. R. B. EVERED and T. RUDLING. London. Improvements in pillars and electroliers or pendants for electric lamps.

October 10, 1890.

16,064. J. K. PUMPELLY and F. BUTTERWORTH. Glasgow. Improvements in electrical secondary batteries.
16,104. W. T. PRESSLAND. London. Improvements in self-contained electric bells and indicators.
16,110. T. PARKER, J. H. WOODWARD, and E. S. G. REES. London. Improvements in the distribution of electricity.
16,124. D. FAIRGRIEVE. London. Improvements in electric clocks.

October 11, 1890.

16,136. H. J. DOWSING and H. S. RICE. London. Improvements in coin-freed apparatus for obtaining a current of electricity for producing electric light, or for other purposes.
16,153. D. RYLANDS. Barnsley. Improved means of manufacturing glass conduits or tubes for electrical or other purposes.
16,156. J. JOHNSTONE. Edinburgh. Improving mains for carrying currents of electric matter.
16,221. A. RECKENZAUN. London. Improvements in electric meters.
16,222. A. L. SHEPARD. London. Improvements in lanterns or lamps for arc electric lights, and in posts or columns therefor.
16,223. H. BURROW. Norwich. Improvements in the parts of electric meters connecting the movement of the solenoid with the calculating train.

SPECIFICATIONS PUBLISHED.

1889.

14,867. IMRAY (Walton). Electrical conductors. (Price 11d.)
15,609. BACHMANN. Electrical railway switch, &c. (Price 8d.)
16,165. LANCASTER (Grivolas). Electric coupling for cut-outs. (Price 6d.)
17,124. THOMPSON (the Westinghouse Electric Company). Electric circuits. (Price 8d.)
17,274. GRIMSTON (Jacob). Electric switch. (Price 6d.)
17,694. WILSON. Electrical Watt meter. (Price 8d.)
17,831. SHERRIN. Electric battery carbon, &c. (Price 6d.)
18,159. WEUSTE. Electric contact apparatus. (Price 8d.)
18,360. RENSHAW. Dynamos. (Price 6d.)
19,195. SUMMERS. Laying electric, &c., wires in streets. (Price 6d.)
19,835. PERLS, M. and T. Electrical signalling apparatus for railways. (Price 1s. 1d.)

1890.

5,474. LYON and LESLIE. Regulating electric circuits. (Price 8d.)
6,156. SCHULTZ. Electrical switch. (Price 6d.)
6,878. SCHMITZ. Electric alarm for clocks. (Price 8d.)
8,599. ANDERSON. Generating, &c., electric currents. (Price 8d.)
8,800. THOMPSON (Peral). Electric accumulators. (Price 8d.)
8,892. MUIRHEAD and WRIGHT. Electrical conductors, &c. (Price 6d.)
10,076. GOULD and GOTTSCHALK. Electrical conductors. (Price 6d.)
10,421. BRADFORD. Preventing accidents from overheating of electrical wires. (Price 6d.)
10,868. DE PASS (Marès). Electricity meters. (Price 8d.)
11,017. THOMPSON (Lynch). Electric railways, &c. (Price 8d.)
11,402. PFINGST. Couplings for electric railway vehicles. (Price 8d.)
11,465. DEWEY. Rivetting by electricity. (Price 8d.)
11,699. NAHUSEN. Obtaining chlorine, &c., by electricity. (Price 4d.)
12,247. LAKE (Pyle). Electric lamps. (Price 8d.)
12,566. RUSSEL. Electric arc lamps. (Price 8d.)
12,628. FOWLER. Welding metals by electricity. (Price 8d.)
13,006. LAKE (Thomson). Welding metals by electricity. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Woodhouse and Rawson United (Limited).

A general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on October 10th, under the presidency of the Right Hon. Lord Aberdare, P.C., G.C.B.

The SECRETARY (Mr. George Worrall) read the notice convening the meeting.

The CHAIRMAN: Ladies and Gentlemen,—Before moving the adoption of the report there are two points in it to which, for fear of misapprehension, I desire to call your attention. One is, that the ordinary shares, on which half the capital remains uncalled, are the shares taken by the public. The shares allotted to the vendors are, of course, fully paid, as shown by the balance-sheet. The other point to which I desire to refer is this—we mention in our report that the Sociédad Española del Electricidad in Barcelona has placed its lighting in the hands of this Company. The actual contract, however, was made between that Company and Woodhouse and Rawson (Limited). The contract was taken over by us, and at the present time the Barcelona Company is engaged in carrying out our suggestion. There are two ways in which a Board of Directors may report to their shareholders their proceedings for the past year: they may either present a report containing net results in the briefest and most succinct form, leaving to the Chairman the task of supplying in his speech the facts and events which he thinks likely to interest the shareholders; or they may add to the bare statement of results a detailed account of their operations and of the development of their undertaking, thus enabling those interested to form an estimate of their actual position and to forecast the prospects of the future. This latter method, which has the advantage of placing on permanent record the actual position of the Company, and of giving to absent shareholders information which would otherwise be denied them, seems specially advisable at the first meeting of a Company conducting operations of so varied and extensive a description as ours; for it is clear that much may be stated in a printed report which would be tedious and out of place in a Chairman's speech. We have, therefore, chosen the latter alternative, which has this further advantage—that it relieves the Chairman from the necessity of making a long speech. Those who have carefully studied the report will see how numerous and important our operations are. To some they may, perhaps, seem incongruous, although a little reflection will show that in reality they are closely connected with each other. The manufacturing, supply, and contract departments explain themselves. The development of the business of taking up and bringing out new inventions, by the purchase of patents, by manufacturing under royalties to inventors—all these items of electrical work are closely connected with yet another large and lucrative portion of the business—that of aiding in the formation of Companies to work patents which require capital beyond their means, and to supply the experience which they do not possess. All these branches of electrical business were undertaken by the several Companies which were purchased and absorbed into ours at the time of its formation. They have in their various departments been extended as rapidly as the short period of our existence has permitted. The manufacturing, supply, and contract departments show no inconsiderable improvements in actual performance, and give what I may venture to call well-grounded promise of greater expansion and profits hereafter. With those the report has dealt, I think, at sufficient length, presenting altogether a picture of great activity at home and abroad. In my opinion, these three branches of manufacture, supply, and contract constitute

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the solid basis on which the ultimate success of the Company should rest. But it is obvious that expectations of large profits from these sources can only be gradually realised. Time is needed. We must sow before we can reap. It is unusual and unadvisable to enter minutely into the source of profits of the year in the case of a manufacturing company like ours; but this much I may say: the large profits of the present year, which have enabled us to recommend a dividend at the rate of 15 per cent. per annum, without availing ourselves of the £75,000 deposited with us by the Woodhouse and Rawson (Limited) as a guarantee for a dividend of that amount for three years, which have enabled us to place £25,000 to reserve funds, and to carry forward over £16,000 to next year's account, after writing off £742 against the estimated value of our patents—these large profits have been mainly derived from the fourth branch of our business, as described in the report, viz.:—"The testing and proving of new patents and inventions connected with electrical and engineering science, and their introduction to the public, either by arrangements for working such inventions by this Company, or by assisting the owners in forming separate Companies for working them." Such was the operation of Woodhouse and Rawson (Limited) in introducing the Elmore process, which the present Company are, with every prospect of success, extending over the chief commercial countries of Europe. Such was the formation of the International Okonite Company described in the report. Such, although only incidentally connected with our business, was the disposal of a portion of our premises at West Kensington to the West Kensington Co-operative Stores (Limited)—an operation advantageous to ourselves, and, I trust, to the Company which acquired our property and was launched under our auspices. That there is a certain risk involved in the introduction of new inventions it would be absurd to deny. But this I can honestly say, that these operations have never been undertaken without the most careful inquiry; and that all the judgment, experience and knowledge of affairs possessed by the Board have been exercised before embarking in them. They represent, in fact, but a small, and a very small, portion of the proposals for the Board's assistance in one form or another; the vast majority of which were rejected, not always from distrust of their merits, but because we limited ourselves to the selection of such only as seemed thoroughly sound and of intrinsic value. I have said that the Board had brought its combined faculties to the consideration of all schemes adopted by them; but it is the merest act of justice to our Managing Director, Mr. F. L. Rawson, to say that the success which has hitherto attended us is mainly due to his initiative, and to the extraordinary energy and ability of which he has given proof. Nor can I refrain from expressing my personal sense of gratitude to our vice-chairman, Sir Rawson Rawson, for his great exertions, and for his unremitting attention to the affairs of the Company, especially during the long period when a severe illness with its debilitating consequences had prevented me from giving to those affairs the attention which may fairly be expected from the Chairman. Never was personal aid, at the cost of great labour, more cheerfully given or more effectually. To my other colleagues I venture to tender my grateful acknowledgment of their indulgence to my shortcomings. The report refers, in by no means exaggerated terms, to the unusual demands on the time of the staff, due to the pressure on a new Company engaged in such extensive operations. I beg to add my own acknowledgments, and to recommend warmly to your acceptance the adoption of the resolution for the formation of an employés' pension fund. May I, as my parting contribution to the conduct of your affairs, venture to make some suggestions, the fruit of the past year's experience in the working of the Company? First, I think it very desirable that our capital should be increased, and I trust that the Directors will ere long submit resolutions to you with this object—not, of course, at this meeting. The report has told you that we have already extended considerably the business, and the business premises of the companies we were formed to acquire and consolidate. I am satisfied that these extensions cannot be fully developed, nor made as profitable as they might be, without an addition to your working capital. At present we have, as you know, the use of the capital of the £75,000 deposited with us by Woodhouse and Rawson (Limited), but this money must be replaced at latest two years hence. It might well be worth while to repay it at an earlier date if we can come to a satisfactory arrangement with the liquidators, on fair conditions as to discount and other allowance. It would doubtless be a great advantage to the liquidators to have it repaid, so that they might finally complete their liquidation. This is matter for the future, but I think it advisable to prepare you for possible proposals in this direction. 2nd. My other suggestions relate to an increase in the numbers of your Board, and of the working staff. I have already referred to the labour and responsibility which have rested on your Board, consisting, I may remind you, of only seven members—during the past year in the conduct of your general business, and in sifting the various schemes which have been brought before them. I need not enlarge upon this. The most cursory consideration of the report must make it clear to you that such a business cannot be properly carried on without great expenditure of time and labour, and long and frequent discussions. I see little probability of the diminution of the Directors' work in the near future; and I do not think that the present pressure upon them can long be continued, or that it ought to be. I would, therefore, venture to suggest, with a view to a more effectual division of the work among Committees, that the Board should be increased to nine, the full number authorised by your Articles of Association, and that their remuneration should be increased by the allowance of a percentage on the net profits of the year. I am clearly of opinion that the present remuneration is inadequate for gentlemen who are obliged to give so large a part of their time to the superintendence of this great and growing business, and that your interests will gain by treating them more liberally. Now as to the working staff. With the best will in the world, the Board of Directors can be little more than a consultative and critical body. The initiative, no less than the details of the Company's operations, must rest with the executive staff. Ours is excellent as far as it goes, but no man ought to be called upon to do all the work which is imposed on many of your officers, and more especially on your Managing Director. There must, I venture to assert, be some further division of labour, the cost of which will be inconsiderable as compared with the increased efficiency of external and internal management. If you approve in principle of these suggestions you will doubtless intrust the Board with the duty of working them out. It now only remains for me to thank you for the patience with which you have listened to me, to echo the congratulations of the report on the achievements of last year, and on the present position and prospects of the Company, and to express the earnest hope that you will, with a unanimous vote, support the Board in their efforts to give stability to an enterprise which has begun so well. The report mentions my resignation, and the reasons for it, and I trust you will think them sufficient. My habitual residence during the greater part of the year is nearly 200 miles from London, and I am thus compelled to choose between the exhaustion of long and frequent journeys or absence from the meetings of the Board. I cannot reconcile myself to either alternative, and therefore resign. Let me, however, congratulate you on the new Director proposed for your acceptance. The high character of Sir Edward Thornton for ability and honour, and his distinguished career as a Foreign Minister, give ample pledge of his capacity to watch over and advance the interests of your Company. Should you re-elect Sir Rawson Rawson as a Director, it is right to inform you that it is the intention of the Board to request him to assume the chairmanship. After what I have already said of my appreciation of Sir Rawson Rawson, I need hardly say how entirely I concur in the propriety of their choice. There is one other point which I desire to refer to, namely, that I am happy to inform you that the affairs of Woodhouse and Rawson (Limited) may be considered settled. You cannot know how long and vexatious has been the endeavour to bring that settlement to an earlier conclusion; but it is now happily arranged, and I am glad to hear that the shares are now on their way to the long-expectant shareholders. I now beg to move:—

"That the Directors' report and accounts for the year ending June 30, 1890, be and are hereby approved."

Sir RAWSON W. RAWSON, K.C.M.G., C.B., seconded the motion.

Mr. ROTHERHAM: I notice that in the balance-sheet the number of ordinary and fully-paid shares is 34,633, and in January last the Company issued a statement to the effect that 36,316 had been issued. I will also ask whether £31,000 is not an unusual amount of cash to be kept in hand. When it is spoken of as being in hand, is it meant that it stands on current account at the bank, or is it in the absolute possession of the Company?

Mr. FREDERICK L. RAWSON: With regard to the first question, I have not the figures before me to answer at a moment's notice; but whatever may have been said, the speaker may be sure that the statements that have been made are absolutely correct. On the next point, namely, cheques and cash in hand, £31,000, odd, that is easily explained when I say that there was a cheque for £30,000 on one transaction that was not paid into the bank on the actual night of closing the balance-sheet, and therefore that has to appear as cheques and cash in hand.

Sir RAWSON RAWSON: It was paid immediately afterwards.

Mr. ROTHERHAM: You say here that the amount of share capital in January, 1890, was 40,000 ordinary shares of £5 each, of which 36,000 odd had been subscribed, including those taken by the vendors.

Mr. RAWSON: At the date of the balance-sheet we had not yet allotted some of the shares to the vendors. The Chairman explained that the shares had just been allotted to the shareholders of Woodhouse and Rawson (Limited). We could not allot them until we were instructed to do so by the liquidators of that Company; but immediately we were so instructed we called a special Board meeting and allotted them. Therefore those shares are now allotted; in fact, the full capital is allotted, as stated in the report, but at the actual date of the balance-sheet the vendors' shares had not been allotted.

Colonel DICKENS: With reference to the £99,000 odd which is put down as profit, what proportion of that has come from *bonâ fide* trade earnings as opposed to the other matters which the Chairman has pointed out?

The CHAIRMAN: I may as well answer this question, and the reply is simply this—that we must decline to enter into those questions. I have told you a large proportion of the profits has been obtained from the other sources; but I do not think it in the interests of the Company, and neither is it usual in the case of a manufacturing Company like ours, to give those explanations, though I quite admit that the question is one which very naturally would arise in the minds of shareholders.

Colonel DICKENS: I only thought it might interest the shareholders that the question should be answered.

Mr. J. B. LEONARD: Will the Chairman state what is the exact position with regard to our obtaining a quotation on the Stock Exchange?

Mr. RAWSON: The position is this: we considered it advisable to run no risk of having our quotation either refused or turned back, and thought it more advisable, although we had made our application to the Stock Exchange for our quotation shortly after the Company was issued, to ask the Committee to keep it back—and they were glad to do so under the pressure of business they were then experiencing—until we had completed our purchase and the capital was all allotted. The papers are now before the Committee, who required certain alterations which we made, and since then they have required some small information. I understand that the application is coming up before the Committee in about a week's time—next Friday, or next Monday week—in order that our quotations may be granted.

The CHAIRMAN then put the motion, which was carried unanimously. He next proposed—

"That this meeting hereby sanctions the declaration by the Directors of a dividend at the rate of 7½ per cent. on the ordinary shares, and 4 per cent. on the Preference shares, making, with the interim dividend of 7½ per cent.

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already paid upon the ordinary shares and 4 *per cent. already paid on the Preference shares, a dividend at the rate of* 15 *per cent. per annum on the ordinary shares and* 8 *per cent. per annum on the Preference shares.*"

I may recall to the minds of our shareholders that our Preference shares are 7 per cent.; but they are entitled to an extra 1 per cent. each year that the ordinary shareholders receive 10 per cent. per annum.

Sir RAWSON RAWSON: I second that. The resolution was carried unanimously.

Sir Rawson W. Rawson and Sir Edward Thornton were re-elected as Directors, and Messrs. Pixley and Co., as Auditors; after which

The CHAIRMAN said: I have been asked to read this resolution:—

"*That the remuneration of the Directors be increased as from the* 30*th day of June,* 1890, *by a commission of* 2 *per cent. per annum upon the net profits of the Company.*"

I have already stated my own strong impression that the amount of their remuneration should be increased. I will not, however, propose this resolution, although I am not interested in it.

General DAVIS seconded the motion.

A SHAREHOLDER: Is the proposed commission on the net or the gross profits?

The CHAIRMAN: On the net profits.

Mr. F. L. RAWSON: As you are aware, it is the intention of the Directors to increase the number of the Board, and this will enable them to recompense the new members.

Mr. HOSTER seconded the motion, which was carried.

Sir R. W. RAWSON proposed a vote of thanks to Lord Aberdare, not only for presiding on the present occasion, but for the part he had taken, and the interest he had shown in supporting the prosperity of the Company.

Mr. SAMUEL POPE, Q.C., in seconding the motion, said: I am seconding this resolution, but I want to disburden my mind of one or two other things as an independent investor. Of course, nobody could imagine that £99,000 a year profit is one capable of being made by manufacturing and supplying electrical apparatus. I am interested in other electrical Companies, because, being of a speculative turn of mind, one is apt to take up new industries as they may arise, in hopes of their development; and one therefore knows pretty much what scale of profit may be possible in such a business. I venture to think that it would not be desirable that we should disclose to those who are our competitors in that class of business the exact profits we may make. They are, no doubt, good profits, but to declare them if they were very large would be to provoke competition, and to declare them if they were very small would be to disclose an unfortunate state of affairs. I think the shareholders may be well content with the amount of profit which is placed to their credit, without being over anxious to ascertain what the particular source is to which it can be attributed. I do invite shareholders at all times most carefully to investigate the accounts, and see that the profits which are placed to credit are real profits, and not merely imaginary or paper profits. That, I should think, would be a matter of considerable interest to every shareholder; but this fact is certified by the accounts, and you must, I think, be well content that you are shareholders in a concern which will pay 15 per cent. upon the capital which you have only had invested for about 12 months. I also desire to say that as long as I sit at the Board I shall certainly advocate the maintenance of strong reserve funds to provide against contingencies. Precisely that which has actuated the shareholder just now in asking us from what source the profit was derived, and your acquiescence in my view that it is impossible to suppose that a great proportion of these profits must not have arisen by the promotion and assistance of other companies, it seems to me that, to be perfectly plain, in order to secure the stability of the business we must of necessity appropriate a certain portion of the profits made, so to speak, to the contingency of their not being permanent profits. In other words, we must strengthen our reserve fund so as to increase the amount which we have to depend upon if in the course of the experience of any year similar success is not obtained in a business, which, after all, is not as steady as a regular trading business, being more or less of a speculative character. On that ground I cheerfully assented to the balance-sheet, because we commence well by setting aside £25,000 of our profits clearly to reserve, and carrying over another £16,000, in fact, appropriating half our profits to contingencies of the future, rather than dividing them greedily now for the purpose merely of increasing the dividend. I do not know that I am revealing any confidence, but since the balance-sheet was made out our profits have not fallen off. We hope to present as satisfactory a balance-sheet next year as we have produced this; but if we should fail to reach that amount we have the reserve. We are acting as prudent shareholders by allowing the accumulation of our profits to meet these contingencies rather than insisting on their immediate division. Those are the principles upon which the business has been conducted. I will not say they are principally or largely due to Mr. Frederick Rawson, but I will say that he has developed a great amount of capacity and energy in carrying them out, whilst the prudence has come from Lord Aberdare and Sir R. W. Rawson. You are, I think, well officered. You have in your managing director a man of the most untiring energy, and speaking for myself (and I do work sometimes)—(laughter)—his work perfectly appals me, and also the energy he brings to bear upon it. In season and out of season, night and day, I believe he has nothing upon his brain but Woodhouse and Rawson United. Sir Rawson, on the other hand, and Lord Aberdare have dealt with our finances in the prudent way which appears in the report. The prudence is due to them; the energy is due to the managing director, and, altogether, I venture to think that we have got reason to congratulate ourselves.

Mr. F. L. RAWSON: I should like, with Lord Aberdare's leave, to call the attention of the shareholders to a fact that it is due to me was not mentioned by his lordship earlier—that is with respect to the employés' pension fund. By the applause that has greeted this reference, I see that it is scarcely necessary to call attention to the advisability of building up such a fund which will give the employés reason to believe that when their work is over they will find that they have done well in remaining with the Company, and not looking about to change whenever any rosy-hued opportunity presents itself to them. I mention this, because we are a little out of order in putting the matter on one side, as we have done. It will be necessary next time we call you together, to have probably an extraordinary general meeting to sanction this proposal; but I feel in the meantime that the Directors have the moral support of the shareholders in dealing with the question in this way.

On the motion of Sir RAWSON W. RAWSON, seconded by Mr. POPE, a cordial vote of thanks was passed to Lord Aberdare.

The CHAIRMAN thanked the meeting for the heartiness of their vote, and a vote of thanks to the Directors for their services in the past year having been carried, the proceedings terminated.

Eastern Extension Australasia and China Telegraph Company (Limited).

Report and accounts of the Directors for the half-year ended June 30, 1890, to be submitted to the thirty-fourth ordinary general meeting, to be held at Winchester House on October 22, 1890, at 2 o'clock:—

The gross receipts, including Government subsidies, have amounted during that period to £254,856. 18s. 10d., against £256,757. 3s. 2d. for the corresponding half-year of 1889.

The working and other expenses, including £24,508. 3s. 10d. for cost of repairs to cables and expenses of ships, absorb £76,670. 9s. 3d., against £73,773. 10s. 2d. for the corresponding period of 1889, leaving a balance of £178,186. 9s. 7d. From this is deducted £2,960. 19s. 7d. for income tax, and £38,549. 14s. 7d. for interest on debentures and contributions to sink-

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ing funds, leaving £136,675. 15s. 5d. as the net profit for the half-year. Against this £1,642. 11s. 11d. has been charged for additions to staff quarters, and £712. 16s. 1d. for expenses in connection with the recent Paris International Telegraph Conference, leaving an available balance of £134,320. 7s. 5d.

One quarterly interim dividend of 1¼ per cent., amounting to £31,250, has been paid during the half-year, and another of like amount will be distributed on the 15th instant, leaving £71,720. 7s. 5d. to be carried forward.

The duplication of the New Zealand Cable and the partial renewal of the Madras-Penang section referred to in the last report have been successfully carried out during the half-year under review; and the cost amounting to £188,433. 15s. 6d. and £80,848. 1s. 3d. respectively has been charged to the general reserve fund, which, after being credited with the profit of £21,103. 3s. 4d. made on the sale of investments, and the interest received during the half-year, now stands at £472,713. 15s. 3d.

The subsidy granted by the Spanish Government in respect of the Manila Cable expired on May 1st last, when the balance of the Five per Cent. Debentures issued to provide the capital for this cable was paid off; and as the interest and sinking fund contributions have now ceased, there will in future be a saving of revenue on this account of about £5,000 per annum.

The Company's £320,000 Six per Cent. Debentures mature for payment at par on February 1, 1891, and your Directors have decided to pay them off on that date by issuing a similar amount of Four per Cent. Mortgage Debenture Stock. An extraordinary general meeting will be held immediately after the ordinary meeting, at which the necessary resolution will be submitted for the shareholders' approval.

Negotiations have been entered into with the Governments of Australasia for the establishment of reduced rates to Australia and New Zealand, and the matter is now under consideration in the colonies.

Arrangements have also been made with the Indian Government for improving the international service; in connection with which the Company has decided to duplicate the Madras-Penang Cable, and a contract has accordingly been entered into with the Telegraph Construction and Maintenance Company for carrying out the work, which is expected to be completed early next year.

During the half-year the Tonquin-Hong-Kong section has been partially renewed by the insertion of 67 nautical miles of new cable, and the operation will be continued as opportunities occur until the line is put into good order.

The Company's maintenance ships have been employed on various cable repairs, but no interruptions materially affecting the revenue have occurred during the past six months. Unfortunately, however, since the close of the half-year telegraphic communication with Australia has been totally interrupted, from the 11th to the 20th July, in consequence of the sudden and simultaneous breaking, through volcanic action, of the three Java-Australian Cables near Banjoewangie (Java). This was the more disappointing as it was only last year that the cable to Western Australia was laid mainly with a view to averting such a contingency; but as only two interruptions from volcanic causes have been experienced during a period of nearly 20 years, it is hoped the cables will now have a long immunity from further trouble of this nature.

Brazilian Submarine Telegraph Company (Limited).

Report of the Directors and the accounts for the half-year ended 30th June, 1890, to be submitted to the thirty-fourth ordinary general meeting, to be held in Room 174, Winchester House, Old Broad Street, E.C., on the 22nd October, 1890, at 12 o'clock noon:—

The revenue for the period amounted to £121,873. 19s. 9d., and the working expenses to £16,492. 5s. 3d. After providing £12,880 for debenture interest and sinking funds, and £1,559. 17s. 1d. for income-tax, there remains a balance of £90,941. 17s. 5d.; to this is added £9,975. 0s. 8d. brought forward from 31st December last, making a total of £100,916. 18s. 1d. A quarterly interim dividend amounting to £19,500 has been paid, and £40,000 transferred to the reserve fund, increasing that fund to £352,626 2s. 11d.

The Directors now recommend the declaration of a final dividend of 3s. per share, making, with the interim dividends, a total dividend of 6 per cent. for the year, and also the payment of a bonus of 3s. per share, both free of income-tax, which together will amount to £39,000, being a distribution in the aggregate of 7½ per cent. for the year ended 30th June, 1890, leaving a balance of £2,416. 18s. 1d. to be carried forward. The dividend and bonus will be payable on the 23rd instant.

On the 31st July last, the sum of £15,300 was transferred to pay off the 153 bonds of the 1884 Issue, drawn for redemption in April last. This repayment reduces the Debenture Debt to £144,200.

The receipts for the half-year include the sum of £1,500 dividend to 31st December, 1889, on the Company's Shares in the African Direct Telegraph Company (Limited).

The various sections of the Company's line are in good working order.

Sir James Anderson and Mr. Frederick Youle retire by rotation at this meeting, and being eligible for re-election as Directors offer themselves accordingly. The two Auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

NEW COMPANIES REGISTERED.

BULLERS (LIMITED).—Registered by Waterlow Brothers and Layton (Limited), 24 and 25, Birchin-lane, E.C., with a capital of £200,000 in £10 shares. Object: to acquire, upon such terms as may be thought fit, all or any of the assets, and to undertake all or any of the liabilities, of the business of engineers, contractors, and otherwise heretofore carried on by a company named Buller, Jobson and Co., now in voluntary liquidation, and to carry on, develop, and extend the said business when acquired; to manufacture, sell, let on hire, and generally to acquire, dispose of, and deal in electrical plant, and in electricity and electric power and other forms of power and energy. The first subscribers are E. Buller, 49, Charlotte-road, Birmingham; H. Jobson, Summer Hill, Kidderminster; E. J. Chambers, Lingwood, St. James-road, Dudley; W. Greenhill, Dudley; E. P. Jobson, Dudley; A. T. Buller, Greystoke, Penrith; J. T. Harris, The Kayes, Stone, Staffordshire. There shall not be less than two nor more than seven Directors. The first are Ernest Wentworth Buller and Howard C. Jobson. Qualification, 100 shares.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended October 10th amounted to £5,479.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—Notice is given that an extraordinary general meeting of this Company will be held at the Company's offices, Winchester House, E.C., on Tuesday, the 21st inst., at 2 o'clock, for the purpose of confirming the following Special Resolution passed at the extraordinary general meeting held on the 30th ult.:—"That Article 71 of the Articles of Association of the Company be and is hereby repealed, and, instead thereof, the following be a regulation of the Company:—The Directors shall receive, as remuneration for their trouble in the execution of their office, the sum of £600 per annum, or such other sum as the Company in general meeting may, from time to time, determine; and such remuneration shall be apportioned by the Directors among themselves in such manner as they shall from time to time think fit."

DIRECT UNITED STATES CABLE COMPANY.—The Board of this Company have declared an interim dividend of 3s. 6d. per share, free of income tax, being at the rate of 3½ per cent per annum, for the quarter ending September 30, 1890; such dividend to be payable on and after the 24th inst.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ending October 10, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,321.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 8.	Price Wednesday, Oct. 15.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 15. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
1,381,380	Stock	15/0	Anglo-American ... xd	50½ 51½	49½ 50½	5 13 11	Jan., Apr., July, Oct	49½	..
2,809,310	Stock	30/0	Do. Preferred ... xd	87 88	85 86	6 13 9	" "	88	85½
2,809,310	Stock	..	Do. Deferred ...	14½ 14¾	13¾ 14¼	.. ..	..	14½	14⅜
25',000	£100	4%	African Direct, 4 per Cent. Debentures ...	98 101	98 101	3 19 3	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine ...	11¾ 12¼	11¾ 12¼	5 6 1	Mar., June, Oct., Dec.	12¼	11⅞
69,200	100	5%	Do. 5 per Cent. Bonds ...	100 102	100 102	4 18 0	January and July ..	100	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series) ...	103 107	103 107	4 13 6	June and December	..	..
$7,216,000	$100	..	Commercial Cables ...	102 104	102 104	.. ..	..	..	..
£16,000	£10	8/0	Cuba Submarine ...	11½ 12	11½ 12	7 1 8	February and August	..	..
6,000	10	10%	Do. Preference 10% ...	17 18	17 18	5 11 1	" "	..	..
12,931	5	6%	Direct Spanish (£4 paid) ... xd	4 4½	3¾ 4½	5 12 11	March & September	4	..
6,000	5	10%	Do. Preference 10% ... xd	9 10	9 10	5 0 0	April and October ..	..	..
60,710	20	3/6	Direct United States ...	10⅜ 10⅝	10⅜ 10⅝	6 11 9	Jan., Apr., July, Oct.	10⅝	10 7/8
400,000	10	5/6	Eastern ... xd	14 14½	13¾ 14½	4 12 0	" "	14 7/8	13 7/8
70,000	10	6%	Do. 6 per Cent. Preference ... xd	15 15½	14¾ 15¼	3 18 8	" "	15 7/8	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock ...	104 107	104 107	3 14 9	May and November	106½	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899 ...	106 109	106 109	4 11 9	February & August	107	106½
250,000	10	2/6	Eastern Extension ... xd	14⅛ 14⅜	14 14¼	4 18 3	Jan., Apr., July, Oct.	14¼	14
320,030	100	6%	Do. 6 per Cent. Debentures, 1891 ...	100 102	100 102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austln. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	102½	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	101 104	101 104	4 16 2	" "	103⅜	..
180,227	10	4/3	Globe Telegraph and Trust ... xd	8⅞ 9⅛	8¾ 9	5 8 4	Jan., Apr., July, Oct.	8⅞	8⅞
180,042	10	6%	Do. 6 per Cent. Preference ... xd	14⅜ 15	14⅜ 14⅞	4 0 8	" "	15	11 1/4
150,000	10	5/0	Great Northern ...	15¾ 16¼	15¾ 16¼	4 12 4	Jan., April, and July	16⅛	15 3/4
15,000	100	5%	Do. 5 per Cent Debentures, 1881 ...	101 104	101 104	4 16 2	January and July ..	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883 ...	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European ...	36 38	36 38	6 11 7	April and October ..	..	..
38,348	10	4/0	London Platino-Brazilian ...	6¼ 7⅛	6¼ 7⅛	5 6 8	..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures ...	105 108	105 103	5 11 1	March & September	..	..
9,000	8	6/0	Reuter's ... xd	8¼ 8⅜	8¼ 8⅜	5 14 4	April and October ..	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust ... xd	113 117	110 114	5 5 3	" "	..	..
15,609	£10	6/6	West African ...	8 9	8½ 9½	5 5 3	.. ..	..	..
290,000	100	5%	Do. 5 per Cent. Debentures ...	98 101	98 101	4 19 0	March & September	99	..
30,000	10	3/0	West Coast of America ...	4½ 5	4½ 5	10 0 0	January and July ..	..	..
150,000	100	8%	Do. Debentures 8% ...	102 107	102 107	7 9 7	June and December	103½	..
88,321	10	Nil.	West India and Panama ...	2⅝ 3⅛	2⅝ 3⅛	.. ..	..	2 1/8	..
34,563	10	6/0	Do. 1st Preference 6% ...	11½ 12	11½ 12	5 0 0	April and October ..	..	..
4,669	10	27/6	Do. 6 p. c. 2nd Pref. ...	14 15	14 15	4 0 0	..	..	..
94,572	15	6/0	Western and Brazilian ...	11½ 11⅝	11½ 11⅝	5 2 3	May and November	11½	..
26,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred ...	6¾ 7⅛	6¾ 7⅛	..	..	..	..
26,986	7½	4/6	Do. 5 per Cent. Deferred ...	4½ 5⅛	4½ 5½	..	..	4 1/8	4⅜
200,000	100	6%	Do. 6 per Cent. Debs., Series "A" ...	103 106	103 106	5 13 2	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	103 106	103 106	5 13 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage ...	122 127	122 127	5 10 3	May and November	..	..
£175,100	£100	6%	Do. 6 per Cent. Sterling Bonds ...	99 103	99 103	5 16 6	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5¾	Consolidated Telephone Const. and Maintenance..	⅛ ⅜	⅛ ⅜	..	Yearly ...	..	..
220,000	£1	3%	Oriental (11s. paid) ...	⅛ ⅜	⅛ ⅜	4 8 3	Yearly ...	..	..
436,700	5	3/0	National ...	4⅜ 4⅝	4½ 4⅝	6 13 4	June and December	4 1/8	4⅜
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref. ...	12½ 12¾	12½ 12¾	4 14 1	June and December	12 5/8	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref. ...	10 10½	10 10½	5 14 3	" "	..	..
209,750	1	⅛	South of England, Ordinary ...	⅛ ⅜	⅛ ⅜	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd)..	2⅝ 3	2⅝ 3	..	..	..	..
55,000	5	1/0	United River Plate ...	3¾ 4	3½ 4	..	January and July ..	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock ...	90 94	90 94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures ...	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
555,000	£5	..	London Electric Supply ...	2⅝ 2⅝	2⅝ 2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£8 paid) ...	5½ 6	5½ 6	..	..	5½	..
42,853	5	..	Westminster Electric Supply ...	1½ 1⅝	2¼ 2⅜	..	..	2⅝	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering ...	1⅛ 1⅜	1⅛ 1⅜	..	..	1⅛	..
63,416	2	0/10	Do. Preference ...	1½ 2	1½ 2	..	..	..	..
20,000	5	7%	Crompton and Co, 7 per Cent. Pref. Shares ...	5½ 5¾	5½ 5¾	..	..	..	..
353,478	5	..	Edison and Swan United ...	.. ..	.. ..	..	..	..	..
409,000	10	..	Electric Construction ...	7⅜ 8⅛	7⅛ 8	..	..	..	..
46,700	2	10/0	Elmore's Patent Copper Depositing ...	5 5¼	5 5½	..	..	5½	5½
20,000	5	..	Fowler-Waring Cables ...	2¼ 3⅛	2½ 3½	..	..	3	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	18½ 19⅓	18½ 19½	5 2 7	February & August	18⅞	18½
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896 ...	100 102	100 102	4 8 3	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid) ...	5¼ 5⅜	5¼ 5⅜	3 12 11	..	5¼	5¼
37,350	12	12/0	Telegraph Construction and Maintenance ...	43 45	43 45	5 6 8	March and July.....	44½	..
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894 ...	100 102	100 102	4 18 0	..	..	..

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(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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NOTES.

Many of the details of the Westinghouse system have been fully explained in Dr. Fleming's recent articles on Electrical Distribution by Transformers; and these are naturally followed in our present issue by the first part of an account of the Sardinia Street Station of the Metropolitan Electric Supply Company. This station has the special interest of being a typical American station equipped throughout with American machinery and appliances. With one exception, none of our leading dynamo makers care to build their own engines. Not only do the Westinghouse Company undertake this work, but their engines are scarcely less remarkable for their originality than are their dynamos; and we understand that no less than forty are kept in stock ready for delivery.

It will be interesting to see how, with imported machinery, the Westinghouse Company, after showing by this excellently arranged station what they can do, will be able to compete with our home manufacturers. One of the solitary advantages to us of American Protection is, that the cost of their labour and material is so high that they cannot compete on the same grounds, nor will their labour-saving devices help them permanently, unless they are continually improved more rapidly than they are adopted in our workshops. But the American manufacturer has an immense advantage in the limitation of his standard sizes. Our dynamo builders are fully alive to the fact, but they continue to offer a very much larger choice of standard sizes, and they generally need but little inducement to build machines to suit the special requirements of an order. The magnificent catalogue of the Westinghouse Company relating to "incandescent apparatus" offers only five sizes of alternating-current dynamos for 1,000 or 2,000 volts. In the latest price list of English manufacture that we have received we find five sheets of continuous-current dynamos at five different voltages, with twelve different sizes on each sheet. These may be shunt, series, or compound wound, making no less than 180 varieties. Few makers of dynamos offer less than a dozen or fifteen sizes, and in most cases they denote them by mysterious combinations of letters and figures. It is difficult to explain why our manufacturers cannot rid themselves of a fashion which must necessarily increase the cost of production, and one that greatly reduces the immense usefulness of the interchangeable system, which is by no means uniformly adopted even among our best firms.

We print in this issue an instructive Paper, by Mr. Kennelly, dealing with the design of optical ammeters and voltmeters. The investigation will be studied with interest, although it does not tend to the conclusion that instruments of this type are at all likely to successfully compete with others as standards of current or potential. If such optical instruments could be made sufficiently sensitive, they would, undoubtedly, possess many great advantages. The indications would be strictly proportional to current strength; there would be no error due to heating or local magnetic disturbances; and, owing to the absence of any delicate moving parts, the apparatus would be portable and capable of withstanding somewhat rough usage. Unfortunately this is not the case; and, in order to obtain indications of sufficient magnitude, the current density must be increased till a serious heating error is introduced. This arises not in the ordinary way from change of resistance, but more indirectly by alteration of the electro-optic constant of the substance composing the core of the solenoid. The core must be homogeneous for the indications to be sharp; and partly for this reason a liquid is usually employed. If the heating affected different parts of the core equally, the error would not be so serious; but the most efficacious layers of the core are most influenced by the heating, and the indications are not only altered owing to the change of temperature, but at the same time rendered less precise owing to the unequal distribution of heat.

It is often claimed as an advantage possessed by instruments of this type that the current strengths are obtained in absolute measure, from the geometrical dimensions of the solenoid and the optical constants of the core. This is no doubt the case if these quantities are accurately known; but unless that is the case the difficulty of measuring them is so great that it is practically far more convenient and accurate to determine the constant from a calibration with a copper voltmeter, in the same way as used by Sir William Thomson for his standard instruments, than from any such calculations. Neither Sir William Thomson's instruments nor the optical ones can claim to be very easy to manipulate in practice; but the former may be set to a predetermined reading and the current gradually altered till of the right amount, which is then known with great accuracy; while with the latter precision is impossible, owing to the fact that the indications are never very sharp. Any attempt to increase the sensibility seems, moreover, to bring in other defects. Thus, Lord Rayleigh found it inadvisable to increase the rotation by reflecting the light back-

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wards and forwards through the core, as, after several reflections, the light was very much diminished by absorption, and the increase of sensibility so obtained was more than counterbalanced by the indistinctness of the indications.

A ROUGH test for arriving at the efficiency of a transformer appears in a recent number of *Industries*. The primary current is to be measured when the secondary is open, by an alternating current ammeter, and the volts are to be read on a suitable voltmeter such as is always to be found in stations. Half the product of the volts into the current is said to give the loss in the iron. The loss in the copper at any load is calculated from the product of the resistance into the square of the current. An example is given of an efficiency of 85·9 per cent., the value for the same transformer, according to Professor RYAN, being 86·3 per cent. This rough method, says the writer, gives the loss in the iron well within 10 per cent., that is to say, gives the efficiency within 1 per cent. This appears at first to be too good to be true, and does not bear any external evidence of the why and the wherefore. We understand, however, that it is arrived at by considering that the area of the well-known hysteresis curve for low magnetizations is approximately one half of that of the rectangle formed by its limiting co-ordinates. But in the curves which we have examined with this feature in view, we find that the error is very considerably more than 10 per cent.

ELECTRIC lighting has a sufficiently hard struggle with competition by gas and oil, with obstruction by local authorities, with embarrassment by over-legislation, with restraint by innumerable "safety" rules, though these can be met with more or less success by properly organised efforts; but a far more prejudicial and by no means unimportant annoyance to the industry is caused by the sensational accounts in the daily press of accidents connected with electricity. The daily newspaper selects with care and pays with liberality its musical and art critics, and seeks experienced men for war correspondents and reviewers. But when any scientific or even engineering matter has to be dealt with, it is apparently handed over to the dramatic or the melo-dramatic critic. The public are beginning to learn that most of the American overhead-wire accidents are grossly exaggerated or without foundation; and, what is more important, that hardly anything of the kind take place in this country. This week an account, couched in the most alarming language, has been going round the papers, describing the explosion of accumulators on a yacht. "The electricians," it is said, "who have investigated the matter, express themselves quite unable to account for the disaster; and regard it as an entirely new experience from every point of view."

THE accounts which we have seen do not contain sufficient evidence to prove that the smashing of the batteries was due to anything connected with themselves or with electricity; but we are ready to admit that towards the end of the process of charging them, the hydrogen given off may, if confined in an entirely unventilated chamber, form an explosive mixture with the atmosphere, and that an explosion might thus ensue. But we must add that such accidents are extremely rare, no more serious case has ever yet been recorded than that which occurred on a tramcar in July last, and we have heard of the occasional blowing off of the lid of a cell. The sting of these paragraphs lies in their mysteriousness; scientific men are appealed to; the electric light as a non-explosive is said to be still a matter for future invention. The room or closet containing accumulators should be ventilated under any circumstances; and, even if the accommodation is so small as to consist merely of a box or case, there is little difficulty in providing for sufficient access of fresh air to prevent the formation of an explosive mixture.

Magdeburg.—The town of Magdeburg is about to raise a loan of 33 million marks, of which 1½ million (£75,000) will be applied to the erection of a central lighting station.

Blankenburg.—The municipal authorities have decided to accept the tender of Messrs. Naglo Bros., of Berlin, for the equipment of an electric light installation, at a cost of 127,000 marks.

Penzance.—The Town Council have decided to oppose the application of the Penzance Electric Lighting Company for a Provisional Order, and have resolved to obtain an Order themselves.

Chiswick Local Board.—At the last meeting of this Board the Clerk submitted the Parliamentary notice of application for Provisional Order authorising the Board to manufacture and supply electric light in the parish of Chiswick.

Stuttgart.—The telephone network at Stuttgart has reached such proportions that a further extension of overhead wires has been forbidden by the authorities, who have accordingly ordered that in future the lines must be laid underground.

Submarine Telephonic Communications.—Experiments in telephonic communication between Cuxhaven and Heligoland by the North Sea cable have recently been made by the German Post Office authorities. The results were very satisfactory. The distance is about 50 miles.

The United States Telpherage Patent.—In the interference action with regard to the application of Rudolph H. Hunter, filed May 22, 1886, and the patent No. 305,194, to Fleeming Jenkin, granted September 16, 1884, on application filed February 1, 1883, the examiners-in-chief of the United States Patent Office have reversed the decision recently made by the examiner of interferences in favour of Hunter.

Whitby.—At a special meeting of the Whitby District Local Board, held on Monday last, the notices served on the Board by the Yorkshire House-to-House Electricity Company and the East Coast Electric Light and Power Supply Company were taken into consideration. It was unanimously decided that the Board should apply for a Provisional Order, and a sub-committee was appointed to see the matter carried into effect.

Exeter.—At their last meeting the Town Council refused consent to the Exeter Electric Light Company's Provisional Order, and decided to apply for an order themselves This decision was come to owing to the Special Committee being unable to agree with the Electric Light Company as to the purchase clauses to be inserted in the Company's proposed Order.

Keswick Electric Light Company.—In consequence of the large consumption in Keswick of the light supplied by this Company, the Directors find it necessary to increase the plant so as to enable them to meet the growing demand. In order to put down a new turbine, dynamo and exciter, an outlay of at least £1,400 will be required. They have, therefore, resolved to issue the remainder of the shares.

The Institution of Electrical Engineers.—The conversazione of the Institution of Electrical Engineers will be held on Wednesday evening, November 19th, in the Galleries of the Royal Institute of Painters in Water Colours.—The second annual dinner of the Institution will be held at the Criterion Res-

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taurant, on Thursday, November 20th. Members who desire to attend should give notice as early as possible to the secretary, Mr. F. H. Webb.

Telegraphic Extensions in Northern Russia.—The Russian Imperial Telegraph Department propose next spring to run a telegraph line from Kola, on the Arctic Ocean, to the Scandinavian frontier, which is distant some 90 miles. Kola is the most northern town in European Russia, and is a provincial capital of some importance. Hitherto the only means of communication between Kola and the Scandinavian frontier has been a bi-weekly postal service.

Flamborough.—Efforts have from time to time been made to carry out the construction of a railway from Flamborough to the North-Eastern Station, two and a-half miles away from the town, but the promoters have hitherto failed to realise their schemes. The last proposal is to construct an electric railway. The need for some sort of railway between Flamborough and the inland towns is great, and the idea of an electric railway is meeting with considerable support.

Electric Traction v. Cable Traction.—On August 1, 1873, early in the morning, says *Electric Power*, the first trial trip of the cable railway system was made in San Francisco. The inventor was A. S. Hallidie. To-day, after 17 years, there are 44 cable railways in the United States. In August, 1884, the first electric railway was started in Cleveland, Ohio, on the Bentley Knight conduit system. To-day, after six years, there are 263 electric railways in operation or under construction in this country.

Electric Tramway at Bremen.—There have been several unfavourable notices in the local papers on the working of this line. According, however, to the *Elektrotechnische Zeitschrift*, a well-known electrical engineer reports that the service is in every way satisfactory. The cars are said to take the gradients easily and safely; while it is only when the rails are very gritty that any sparking is discernible at the wheels. The lighting of the interiors of the cars is also said to show a great improvement.

Engineering at Cambridge University.—The electors to the Professorship of Mechanism and Applied Mechanics, at Cambridge University, will meet on Wednesday, November 12th, for the purpose of electing a successor to Prof. Stuart. The electors are the Vice Chancellor, Mr. W. Airy, Dr. Besant, Dr. Cayley, Mr. H. Darwin, Mr. Martin, Dr. Phear, and Lord Rayleigh. An engineering laboratory is to be established, for the equipment of which it is thought there will be little difficulty in raising funds. The salary attached to the post will be £700 a year.

Melbourne.—At a recent meeting of the Melbourne City Council a resolution was carried, thanking the Gas Company and the Union Electric Light Company for the efforts they had made to keep the city lighted during the present dispute in the shipping trade. The Public Works Committee reported that the Mayor had entered into an arrangement with the Union Electric Company to erect 15 arc lamps at the chief street intersections, and to keep them lighted all night, as well as 45 other arc lamps already fixed by the Company in the streets, at a cost of £48 per week.

O.S.A. Dinner.—On Friday last the annual dinner of the Old Students' Association of the City and Guilds of London Institute was held at the Holborn Restaurant. About sixty members and several visitors enjoyed a most agreeable evening. Among other speakers, Mr. Saunders, Q.C., replied for the Institute, and Sir Owen Roberts for the visitors. It was evident that a cordial feeling exists not only between the professors and the students, but between the latter and the governing body, who take a warm interest in their concerns, and appreciate the great success which has attended their efforts.

Telegraph Cable Construction.—The following communication has been issued by the Foreign Office:—A despatch has been received from Her Majesty's Ambassador at Madrid, enclosing copies of a Royal decree authorising fresh tenders to be invited for the construction of the telegraph cables between the Peninsula and the Spanish possessions on the North Coast of Africa. The new conditions are slightly different to those previously laid down. None of the tenders received in answer to the first application have been accepted. The conditions (in Spanish) may be seen at the Commercial Department of the Foreign Office between the hours of 11 and 5.

London Electric Supply Company.—The machinery at the Deptford station is working in a highly satisfactory manner. The current that is now being daily generated is greater than any that has yet been supplied. Both the 1,500 horse-power engines and dynamos are working without any hitch, and have been supplying current continuously to about 40,000 lamps every night for about a fortnight through the Ferranti mains. The disturbing effect on the telegraph lines has now been reduced to an insignificant and hardly appreciable magnitude. For reasons which are not yet thoroughly understood there is a rise of pressure of nearly 50 per cent. at the ends of the mains.

The Frankfort Electrotechnical School.—The Frankfort-on-Main Physical Society has founded an electrotechnical school, where it is intended that the technical education of lads who have served their time in mechanical workshops should be completed. It is proposed to impart sufficient theoretical and practical instruction to enable the students to become trustworthy foremen capable of looking after installation and other electrical work. Candidates for admission to the courses have to produce their certificates of apprenticeship, and to give evidence of possessing sufficient knowledge of elementary mathematics to obtain the full benefit of the instruction given. The annual fee is 100 marks, *plus* a deposit of 10 marks, which goes to the repair of instruments accidentally injured in experimental work.

Electrical Fog Signal.—Experiments with the Andrews electrical fog-signal have recently taken place at Bowes Park, on the Great Northern Railway, in the presence of a large number of railway engineers and directors. In this system an insulated rail is laid down parallel with the ordinary rails; and the current is conveyed to the engine by means of a metallic brush affixed to the footboard. There is an illuminated dial fixed on the weather-board of the engine, with a miniature signal and a gong to direct the attention of the driver to the sign given on the engine. In the signal-box are other miniature signals showing the signalman that the driver has received correctly the signal. The signal may be brought into action by the signalman immediately upon a fog coming on simply by moving a switch.

Cataphoric Medication.—The question of the absorption into the skin of solutions by means of electric currents has been "says Dr. S. Ehrmann, of Vienna," the subject of many experiments with me since Prof. Wagner first started the discussion by his researches on the cataphoresis of cocaine; and I have at last hit on a very simple experiment. Take two similar glass vessels, with zinc electrodes at the bottom, and filled with a very weak solution of methyl-blue; and if an individual places one of his hands in each vessel, then when a constant current of from 10 to 20 milliamperes is allowed to pass for five or ten minutes the hand in the anode vessel becomes covered with blue spots, whilst the other is not marked. The spots appear most on the back of the hand, where the hair and fatty glands are situated. In the palm and round the nails they do not occur.

The Endowment of Research and Invention.—According to *La Lumière Electrique*, the French Government recently proposed to divide the quarter of a million sterling arising from the Henri Giffard bequest among the several Government departments, for the purpose of assisting various urgent departmental schemes; and the necessary decrees were presented to the President of the Republic for his signature. Energetic protests were, however, made against this mode of appropriating this fund, and the intention of the authorities now is to found an institution for the purpose of stimulating and assisting the spirit of invention and research, to help men having "happy ideas" to put them into practice, and to endow France with an institution which shall be free from scientific and administrative routine without becoming a refuge of utopians. As our contemporary remarks, "this problem is not an easy one, and we may anticipate that there will be numerous experiments before a thoroughly satisfactory solution is arrived at."

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The Pazzalo-Lugano Funicular Electric Tramway. — The funicular electric tramway between Pazzalo and Lugano has lately come into operation. Theline, which is of one metre gauge, is close upon a mile long, and runs along the shore of the Lake of Lugano and up Mont Salvatore. Power is obtained from a waterfall which actuates two Girard turbines, each of which drives a dynamo. One of these machines is an alternator, and supplies lights at Lugano and Pazzalo. The second dynamo is a continuous current machine, and gives 1,800 volts and 22 amperes at 700 revolutions; the motor at Pazzalo develops 40 horse-power at the same speed. The maximum gradient is one of 38 per cent. The track being double, a car is attached to either end of the cable, so that the tractive effort required is considerably reduced. Each car weighs 4½ tons, and can carry 32 passengers. A 50 horse-power steam engine is kept in reserve at Pazzalo.

The Canadian Fire Insurance Companies and the Electric Light.—The Canadian Board of Fire Underwriters are talking, says the *Electrical, Mechanical and Milling News*, of compelling the electric light construction companies to pay the cost of a special inspector to look after properties in which electricity is used as an illuminant. Our contemporary is of opinion that the arguments in favour of this course are scarcely logical. The insurance companies say that they consider electric lighting, when properly installed, to be the safest known method of artificial illumination. At present the insurance companies pay the cost of inspection themselves, and why they should now want to tax the "safest method" with an inspector's salary is beyond comprehension. The total amount paid in the City of Toronto for losses by the insurance companies on account of electric lighting during the past seven years has been *ten dollars;* two dollars of which was refunded, with exceptional honesty, by their client because his repairs only cost him eight!

Jamaica Exhibition.—A meeting of the English committee of this Exhibition was held last week at the Hôtel Métropole. Lord Knutsford, the honorary president, being unable to attend, the chair was occupied by Mr. C. Washington Eves. The Chairman announced that an Imperial grant of £1,000 had been approved by Parliament and paid. Mr. S. Lee Bapty, having been appointed general manager, was introduced to the meeting by the Chairman. Mr. Bapty reported that a large number of applications to exhibit had been received. He anticipated that more applications would be received from Great Britain than could be accommodated. Progress was reported with regard to the building operations, and letters were read from Governor Sir H. A. Blake expressing confidence in the success of the Exhibition. An additional annexe, providing accommodation for exhibits to the extent of 26,000 square feet, had been determined upon, and a fine art gallery was being arranged. Canada and several of the West India colonies would be well represented. Reports were submitted as to electric lighting and other matters.

Edinburgh Exhibition.—The following firms, amongst others, have received awards at this Exhibition:—Complimentary list of exhibitors: Diploma of honour—Robey and Co., steam engines; Ruston and Proctor, 25 horse-power compound engine. Gold medal—Andrew and Co. (Reddish), Double-acting gas engine; Priestman Bros., petroleum engine. Silver medal—Bertrams (Edinburgh), engine-driving dynamo.—General list of exhibitors:—Diploma of honour — Crossley Brothers, gas engines. Gold medal—Davey, Paxman, and Co, engine and boiler; Davis and Timmins, machine screws, electrical fittings, &c.; Elmore's Patent Copper Depositing Company, copper piping made by Company's process; Fielding and Platt (Gloucester), gas engine. Silver medal—Dick, Kerr, and Co., gas engines; Gandy Belt Manufacturing Company (Liverpool), cotton belting; King, Brown, and Co. (Edinburgh), high-speed engine; Rossendale Belting Company (Manchester), hair belting with anti-friction edge. We understand that there is a difference between the awarding and the presentation of a medal in the case of the Edinburgh Exhibition. Those who wish to have actual medals may obtain them by paying for them.

Lighting of the Reading Library.—The contract between the Reading Library Committee and the Reading Electric Lighting Company, according to a communication by the Librarian, specifies that the sum of £80 per annum shall be paid for supplying the current to the eight arc lamps in use in the library and reading-rooms, for providing the necessary carbons, and for keeping the lamps in order. It was considered that 100 glow lamps, of eight candle-power each, would be required to illuminate the library and rooms for reading purposes only, and to supply the electric current and renewals to these lamps would cost £150 per annum. To supply the current and renewals to a sufficient number of large incandescent, or "Sunbeam" lamps, of 300 candle-power each, would cost about £250 per annum. The arc lamps in operation at Reading are nominally of 1,200 candle-power each; some 50 to 60 per cent. of the illumination is, however, absorbed by the globes. The total illuminating power at the library is, therefore, equal to about 4,320 candles. The cost for the gas consumed in the library and reading-rooms last year was £79 odd, while the total illuminating power was equal to some 1,360 candles.

Konigsberg.—The five-wire central station at Königsberg, the first of its kind in Germany, will shortly come into operation. The total capacity of this station is at present 600 horse-power. There are two groups of engines and dynamos, each comprising two triple-expansion engines, and four dynamos. The larger group which has to do the regular evening work consists of two 200 horse-power triple-expansion Schischau engines, each driving two 64 kilowatt dynamos. During the few hours of heaviest work, when two-thirds of the 8,000 lamps are alight, this group will be assisted by the smaller one, consisting of two 100 horse-power engines, each of which drives two 32 kilowatt dynamos. The fall of potential in the leads amounts to 10 volts at full load; the mains and distributing leads are all placed in Monnier conduits. The network is calculated for the supply of 24,000 lamps. Accumulators are used, and special devices have been arranged to prevent them from being placed in the charging circuit before the right tension is reached. During their discharge, if their E.M.F. should fall, additional cells are automatically switched in. Any difference in the voltage of the different parts of the network is shown by a specially-constructed differential voltmeter.

The Behaviour of Lubricating Oils.—In a Paper read at the recent meeting of the American Association for the Advancement of Science at Indianapolis, Mr. J. E. Denton says:—Experiments to determine the coefficient of friction between lubricated rubbing surfaces have been prosecuted for 200 years, and have resulted in the construction of many forms of satisfactory apparatus for such measurement, and such machines are now used by large consumers of oil as a means of discriminating between the lubricating value of the numerous oils offered by manufacturers, and which, while practically alike in fluidity and general oily qualities, are nevertheless claimed to differ in their lubricating qualities. The only difference of behaviour of these lubricating oils shown by the oil-testing machines is such differences of frictional resistance as can be ascribed to the variation in viscosity of the substances in the fluid condition, and this difference of friction fails to account for the well-attested fact that some of the oils are unable to prevent excessive heating and cutting on heavy machinery bearings, which exhibit no such action when lubricated with other oils. Experiments made with a special apparatus constructed for the Lubricating Committee of the Standard Oil Company prove that the overheating of bearings is due to accidental abrasion of the rubbing surfaces, caused by the gradual and inevitable variations of the smoothness of these surfaces by metallic wear. This abrasion generates a comparatively intense heat at some point of the bearings, and tends to vaporise some oils more than others. Oils which are incapable of resisting excessive vaporisation by such accidental heating are those which permit bearings to more frequently overheat than do others not so affected by temperature. The prevailing oil-testing machines fail to reveal such differences in oils. Mr. Denton, therefore, concludes that in order to enable mechanical oil tests to reveal actual differences of lubricating value, each oil must be tested with a series of conditions of the rubbing surfaces and practical feeding devices which involve opportunities for abrasion and overheating.

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ON THE BEST DIMENSIONS FOR STANDARD OPTICAL AMMETERS AND VOLTMETERS.

BY A. E. KENNELLY.

Attention has recently been called to the application of the optical galvanometer to the measurement of current strength, utilising the electro-optical laws of Faraday, Becquerel, Weidermann, and Verdet. The advantage possessed by the method is its almost complete freedom from local magnetic disturbances to which galvanometers as a class are subject, and also its capability of rendering current strengths in absolute measure from purely geometrical data, having given a good rotatory polarication apparatus of the saccharimeter type, and a pure chemical medium for the light to traverse, with a reliable electro-optic constant. Such an instrument is unfitted for practical indicators of current or E.M.F. in engineering practice, and can at present be only used advantageously for standard measurements. In these, however, it possesses a very fair degree of accuracy, and a convenience in manipulation second only to that afforded in the use of the gravitational measurers of Sir William Thomson. It is proposed to discuss the conditions that lead to the best construction of the instrument, as these apparently have not yet been published. The liquid meduim generally adopted is bisulphide of carbon, which can be obtained in the requisite degree of purity without difficulty, which possesses a high, though by no means the highest specific rotatory power among liquids, and which has probably received the most careful determination of that power under the title of the "Verdet Constant."

It will be advisable to examine mathematically the best conditions for securing the greatest amplitude of rotation for any given current, and the limitations to which that amplitude is subject. The practical formulas for determining the best winding for the various classes of instruments will then directly follow.

Let c be the current flowing through the helix (amperes).
" e " " E.M.F. acting on the helix, or the potential difference between its terminals, asssumed steady (volts).
" r " " resistance of the helix (ohms).
" l " " length of the helix (centimetres).
" a " " internal radius of. the helix (centimetres).
" b " " external radius of the helix (centimetres).
" m " " mass of the helix (grammes).
" n " " number of turns in the helix per centimetre of its length.
" N " " total number of turns in the helix or ln.
" σ " " specific gravity of the conductor in the helix.
" d " " diameter of the conductor (centimetres).
" D " " diameter of the covered wire.
" v " " magnetic potential difference between the ends of the helix axis of the liquid column in absolute measure.
" ϕ " " "Verdet Constant," or the rotation in the medium of a plane polarised series of luminous vibrations, with given frequency, for unit electromagnetic potential difference expressed in minutes of arc.
" θ " " observed angle of rotation (minutes).
" ρ " " resistivity of the conductor at working temperature (ohms per cubic centimetre).
" h " " heat developed by the current in the helix per square centimetre of its external surface per second (watts).

Then the fundamental electro-optic law is:—

$$\theta = v\phi \quad \ldots\ldots\ldots \quad (1)$$

To a first approximation, very nearly accurate for a long, thin helix,

$$v = \frac{4\pi}{10} c\,\mathrm{N} = \frac{4\pi e n l}{10 r} \quad \ldots\ldots \quad (2)$$

The correction for the reduction in magneto-motive force due to the influence of the free solenoidal poles is a simple one. It can be deferred for the moment if it is remarked that in virtue of this correction the actual length (l) of the helix becomes a virtual length, L, where $\mathrm{L} = l - \lambda$, and consequently equation (1) becomes strictly

$$\theta = \frac{4\pi n e \phi \mathrm{L}}{10 r} \quad \ldots\ldots\ldots \quad (3)$$

In what follows, the uncorrected length l only will be considered, since the correction is usually small, and can always be separately introduced.

Developing N and r of (2) in terms of the dimensions of the solenoid,

$$\mathrm{N} = \frac{l(b-a)}{\mathrm{D}^2} \quad \ldots\ldots\ldots \quad (4)$$

$$r = \frac{4\rho l (b^2 - a^2)}{\mathrm{D}^2 d^2} \quad \ldots\ldots\ldots \quad (5)$$

This is on the assumption, realisable with care in practice, that the wire is uniformly and accurately wound on the solenoid without paper or other insulating material between the layers or turns. This assumption is involved in all that follows. Substituting in (1) and (2)

$$\theta = \frac{\pi e \phi d^2}{10\rho(b+a)} \quad \ldots\ldots\ldots \quad (6)$$

This shows that the amplitude of rotation obtainable from a helix for a given potential difference between the terminals, that is when used as a voltmeter, does not in the first instance depend upon the length of the helix, but varies as the sectional area of the wire directly, and as the mean radius of the winding inversely. This means that for a given winding space, the amplitude would increase indefinitely with the sectional area of the wire used in winding the instrument. Practically, however, the limit is reached owing to the strength of the current in the helix, and the heat that current would generate during the measurement. This heat not only alters r, affects to a certain extent the specific rotary power ϕ, but also interferes with the working of the apparatus by setting up differences of density in the liquid column, thus refracting, scattering, and obscuring the beam of light. A jacket of insulating circulating water, if inserted between the tube and helix, would certainly act as a shield, but would by no means add to the convenience of the instrument, while it would tend to reduce its effectiveness in another direction by increasing the radius of the helix. In any case, the variation in r due to any considerable rise of temperature would interfere greatly with the use of the apparatus for standard measurements. It therefore becomes necessary to so limit d that the heat generated may escape from the surface of the helix without materially raising its temperature, or that h may not exceed a certain limiting value.

This value is, strictly speaking, a function of a and b; but for practical purposes we may fairly consider the limit to be $h = 0{\cdot}02$ watts per square cm. for intermittent and measuring currents, and $h = 0{\cdot}01$ for a helix that has to remain in circuit and sustain a permanent current.

Expressing d in terms of h and the general dimensions

$$d^2\mathrm{D}^2 = \frac{8 h l b \pi l^2 \rho (b^2 - a^2)}{e^2}, \quad \ldots \quad (7)$$

and

$$b = a\sqrt{1 + \frac{4m}{\pi q}\left(\frac{\mathrm{D}}{d}\right)^2}, \quad \ldots\ldots \quad (8)$$

where $q = \pi a^2 \sigma l$, or the mass of the space within the helix if converted into copper

Hence,

$$d^2 = \frac{l}{e}\sqrt{\frac{32 h \rho m b}{\pi \sigma}}, \quad \ldots \quad (9)$$

and

$$\theta = \frac{4\pi\phi}{10}\sqrt{\frac{lm}{a}} \times \sqrt{\frac{2h}{\pi\rho\sigma}} \times \frac{b}{a+b} \quad \ldots \quad (10)$$

The last equation shows that when the current in the helix reaches the heat limit the rotation obtainable is independent of the E.M.F., varies approximately as the square root of the mass of copper in the winding, and also as the square root of the dimensional ratio $\frac{l}{a}$. In other words, the same amplitude should be obtainable from all well-designed instruments, whether am-

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meters or voltmeters, and it is almost useless with a given weight of wire to increase the length of helix, notwithstanding the greater service obtained, if the internal diameter be increased in the same proportion.

Taking $\sigma = 8{\cdot}95$, $\rho = 1{\cdot}8 \times 10^{-6}$ values for copper.

$$\theta = 250\phi \sqrt{\frac{lmh}{a}} \times \frac{b}{a+b}. \quad . \quad . \quad . \quad . \quad . \quad (11)$$

For the D line of the sodium flame ϕ is given by Lord Rayleigh and A. Koepsel at 18°C, as $4{\cdot}20 \times 10^{-2}$, so that

$$\theta = 10{\cdot}50 \sqrt{\frac{lmh}{a}} \times \frac{b}{a+b}. \quad . \quad . \quad . \quad . \quad . \quad (12)$$

For intermittent currents and $h = 0{\cdot}02$

$$\theta = 1{\cdot}485 \sqrt{\frac{lm}{a}} \times \frac{b}{a+b}. \quad . \quad . \quad . \quad . \quad . \quad (13)$$

For permanent currents, and $h = 0\ 01$

$$\theta = 1{\cdot}05 \sqrt{\frac{lm}{a}} \times \frac{b}{a+b}. \quad . \quad . \quad . \quad . \quad . \quad (14)$$

It is difficult to make l more than one metre, if only from the absorption of light in so long a column; also it is difficult to make the internal diameter of the helix less than 1 cm.; hence the practical limit of $\sqrt{\frac{l}{a}}$ may be estimated at 10. Again, a fair maximum for m would be 10,000, or 22lb. of copper, and with the superior limit of the fraction $\frac{b}{a+b}$, namely, unity, we have for intermittent currents, maximum $\theta = 1485'$ or 24°45', and for permanent currents, maximum $\theta = 1050'$ or 17°30'.

It might be possible to double the amplitude of rotation by arranging a mirror at one end of the tube and causing the light to traverse the length of the liquid column twice in succession, but this is not only inconvenient but probably needs an increase of illumination and of internal radius. It is also to be regretted that no simple and definite standard of illumination can yet be adopted with a higher frequency than the sodium flame. Thus a monochromatic flame radiating violet light of the wave length G would more than double the amplitude of rotation.

Assuming the above, then, to be the practical limits of amplitude with instruments operating at their maximum capacity, the degree of accuracy obtainable depends only upon the degree of precision with which the amplitude can be measured. With a good polarimeter, and particularly with a repeating circle to eliminate errors of eccentricity, the limit of precision on steady currents should certainly not exceed 2′ of arc; and in fact when repeated measurements can be made, a mean rotation can always be found whose probable error is less than 1′, so that the degree of precision at full capacity attainable is certainly one part in 750, and probably one part in 1,500 with care and under the most favourable circumstances.

The best windings for such instruments may next be considered, and first for voltmeters. Suppose the length of the helix given, the internal radius a, and the total mass of wire m to be wound, the maximum voltage to be measured being also given. It is to be remarked that the degree of precision in the observations with any instrument diminish as the current measured descends below the maximum current so that they work best at full load. The diameter of the wire to be used can be found from equation 9. In solving it a trial value can be given by estimation to the fraction $\left(\frac{D}{d}\right)^2$, and if this value should be found inaccurate by the result, the formula should be used again with the adjusted value. As an example, let it be required to determine the best winding for a voltmeter to operate at a maximum limit of 130 volts, the length of the helix being 62cms. between flanges, and its radius 1·1cms., allowing 10lb. of wire in the helix, and a heat limit of 0·02 (intermittent currents).

Assuming $\left(\frac{D}{d}\right)^2 = 1{\cdot}2$, formula (8) gives

$$b = 1{\cdot}1 \sqrt{1 + \frac{4 \times 10 \times 453{\cdot}6 \times 1{\cdot}2}{3{\cdot}142 \times 3{\cdot}142 \times 62 \times 1{\cdot}21 \times 8{\cdot}95}}$$
$$= 2{\cdot}277$$

then by (9) $d^2 = \frac{\sqrt{62}}{130} \sqrt{\frac{32 \times 0{\cdot}02 \times 1{\cdot}8 \times 10^{-6} \times 4536 \times 2{\cdot}277}{3{\cdot}142 \times 8{\cdot}95}}$

$$= 12{\cdot}46 \times 10^{-4}$$

or, $$d = 3{\cdot}53 \times 10^{-2} = 0{\cdot}0139''.$$

When covered this wire would have, say, a diameter of 0·017″, so that $\left(\frac{D}{d}\right)^2$ would be 1·474. Repeating the reckoning with this value in place of 1·2, b becomes 2·468, and d 0·0142″, in this case practically the same result.

The amplitude to be expected from the instrument at 130 volts would be by (13)

$$= 1{\cdot}466 \sqrt{\frac{62 \times 4536}{1{\cdot}1}} \times \frac{2{\cdot}468}{2{\cdot}468 + 1{\cdot}1}.$$

$= 519'$ or 8°·39′ ± subject to correction for polar influence.

Ammeters.—If the instrument is intended for an ammeter, it will be necessary to wind it with coarse wire up to the heat limit. The diameter which will attain this for a given maximum current c ampere, is expressed by the equation

$$d^2 = \frac{c}{\pi} \sqrt{\frac{8\,a\,m\,\rho}{h\,q\,b}}, \quad . \quad . \quad . \quad . \quad (15)$$

where $$b = \sqrt{1 + \frac{4\,m}{\pi\,q} \left(\frac{D}{d}\right)^2}, \text{ as before.}$$

For example, suppose it were required to determine the most effective winding for an optical ammeter of 50 amperes maximum capacity, the length of the tube being 80cms., the winding diameter 1·3, and the weight of copper wire 8lb., the instrument to be kept permanently in circuit ($h = 0{\cdot}01$), since the wire will be coarse $\left(\frac{D}{d}\right)$, will be 1·02, say, then,

$$b = 1{\cdot}3 \sqrt{1 + \frac{4 \times 8 \times 454 \times 1{\cdot}02 \times 1{\cdot}02}{3{\cdot}14 \times 3{\cdot}14 \times 1{\cdot}3 \times 1{\cdot}3 \times 80 \times 8{\cdot}95}}$$
$$= 1{\cdot}956;$$

and $$d^2 = \frac{50}{3{\cdot}14} \sqrt{\frac{8 \times 1{\cdot}3 \times 8 \times 454 \times 1{\cdot}8 \times 10^{-6}}{0{\cdot}01 \times 3{\cdot}14 \times 1{\cdot}3 \times 1{\cdot}3 \times 80 \times 8{\cdot}95 \times 4{\cdot}8}}$$
$$= 0{\cdot}5489,$$
$$d = 0{\cdot}741, \text{ or } 0{\cdot}292''$$

The amplitude obtainable at full load in this case would be by (2) and (4).

$\theta = 235'$, or 3°·55′, subject to slight correction for polar influence.

When the instrument is needed for an ammeter in a circuit containing resistance in such degree that the heat limit cannot be reached, the above formulas no longer apply.

Let E be the E.M.F. of the circuit, and β its resistance.

Then $$c = \frac{E}{\beta + r}$$

whence $$\theta = \frac{4\,\phi\,E}{10(b+a)} \sqrt{\frac{m}{\rho\sigma}} \times \frac{r}{\beta + r}$$

Differentiating this with respect to r, and equating to zero, we have for the maximum value of θ, $r = \beta$, or the resistance of the instrument should equal that of the rest of the circuit, and then

$$\theta = \frac{E\,\phi}{5\sqrt{\beta}\,(b+a)} \sqrt{\frac{m}{\rho\sigma}} \quad . \quad . \quad . \quad . \quad (16)$$

Substituting the values already stated for ρ, σ, and ϕ

$$\theta = \frac{2{\cdot}09\,E}{b+a} \sqrt{\frac{m}{\beta}} \text{ where } b \text{ is found from (8)} \quad . \quad (17)$$

To find d in this case, we have the relation

$$d^2 = \frac{4}{\pi} \sqrt{\frac{m\,\rho}{\beta\,\sigma}} \quad . \quad . \quad . \quad . \quad (18)$$

or $$d = 0{\cdot}0239 \sqrt[4]{\frac{m}{\beta}} \quad . \quad . \quad . \quad . \quad (19)$$

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Thus, suppose the most effective winding to be found for an instrument to indicate the E.M.F. of one Leclanché's cell of 1·5 volts, having a resistance of 1 ohm, using 10lb. of wire, and with the dimensions $l = 6{\cdot}0, a = 1{\cdot}2$, and $m = 4536, \left(\frac{D}{d}\right) = 1{\cdot}18$.

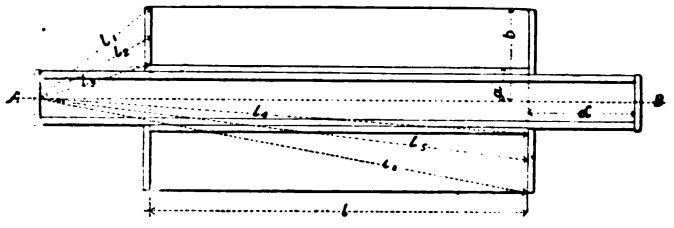
Here $$b = 1{\cdot}2\sqrt{1 + \frac{4 \times 4536 \times 1{\cdot}18 \times 1{\cdot}18}{3{\cdot}14 \times 3{\cdot}14 \times 1{\cdot}2 \times 1{\cdot}2 \times 60 \times 8{\cdot}95}}$$
$$= 2{\cdot}49$$

and $$\theta = \frac{2{\cdot}09 \times 1{\cdot}5}{2{\cdot}49 + 1{\cdot}2}\sqrt{\frac{4536}{1{\cdot}0}}$$
$$= 57' \pm$$

while $$d = 0{\cdot}0239^4\sqrt{\frac{4536}{1}} = 0{\cdot}196 = 0{\cdot}077''.$$

The above formula enable the best size of wire to be found for all the conditions that are usually met with in practice. They have been proved practically reliable by experiment, in the Edison laboratory, the only constants about which there remains any uncertainty being the heat values 0·01, and 0·02, which are estimates fairly reliable.

The formula of correction for the polar influence of the helix upon its *m.m.f.* may be given in conclusion. Let the figure represent a longitudinal section through the axis of the tube



and encircling helix. The tube is supposed to be set symmetrically in the helix, so that the distances d from the extremities to the terminal planes of winding are equal. While not essential, this adjustment is generally easy, and abbreviates the correctional formula. Let l_1, l_3, l_4, l_6, be the distances as shown from one extremity of the axis in the tube, to the circumferences of the coil, while l_2, l_5, are the corresponding distances to the mean circumference. Then equation (3) becomes more strictly

$$\theta = \phi\left\{\frac{4\pi}{10} N c \left(\frac{l_5 - l_2}{l}\right)\right\}. \quad . \quad . \quad . \quad (20)$$

This formula corrects the length of the helix for the polar influence of a similar solenoid of like length and current turns, but of indefinite thinness fixed at the mean circumference. The amount of the correction is with long tubes so small that this approximation is sufficient. When the correction needs to be made with more care the formula is

$$\theta = \frac{2\pi c \phi N}{10 l (b-a)}\left\{b(l_6 - l_1) - a(l_4 - l_3) + D^2 \log_\epsilon\left(\frac{l_6 + b}{l_4 + a}\right) - d^2 \log_\epsilon\left(\frac{l_1 + b}{l_3 + a}\right)\right\} \quad . \quad . \quad . \quad . \quad (21)$$

where $D = l + d$.

This formula is often independently useful for the determination of magnetic differences of potential between points measured along the axis of a homogeneous coil, and equidistant oppositely from its midplane.

As an example suppose the sodium line rotation to be required by computation from a uniform helix of 50,000 turns of length $l = 30$, and radii $a = 2$, $b = 4$, when carrying 0·1 ampere over a tube 34 cm. long.

Formula (3) gives $$\theta = \frac{4}{10} \times 3{\cdot}142 \times 4{\cdot}2 \times 10^{-2} \times 50{,}000 \times 0{\cdot}1$$
$$= 263{\cdot}9' = 4°{\cdot}23'{\cdot}50''.$$

By formula (20) $$\theta = 4{\cdot}2 \times 10^{-2} \times \frac{4}{10} \times 3{\cdot}142 \times 50{,}000 \times 0{\cdot}1 \times \left(\frac{32{\cdot}14 - 3{\cdot}61}{30}\right) = 251{\cdot}1' = 4°{\cdot}11'{\cdot}6''.$$

By (21) $$\theta = \frac{2 \times 3{\cdot}14 \times 0{\cdot}1 \times 4{\cdot}2 \times 10^{-2}}{10 \times 30 \times (4-2)} \times 50{,}000 \times \left\{4(32{\cdot}25 - 4{\cdot}47) - 2(32{\cdot}06 - 2{\cdot}83) + 1024 \log_\epsilon\left(\frac{32{\cdot}25 + 4}{32{\cdot}06 + 2}\right) - 4\log_\epsilon\left(\frac{4{\cdot}473 + 4}{2{\cdot}829 + 2}\right)\right\}$$
$$= 250{\cdot}5' = 4°{\cdot}10'{\cdot}5.$$

The rotation obtained for a given current really varies slightly with the temperature of the bisulphide of carbon liquid.

M. Pichat has given the following formula for reducing the rotation observed at one temperature to that at another:—

$$R_t = R_0(1 - 0{\cdot}00104t - 0{\cdot}000{,}104t^2)$$

where R_t is the rotation at t°C., R_0 being the rotation at zero. From the standard value of $\phi = 4{\cdot}2 + 10^{-2}$, and this formula we have the following table of temperature values for the Verdet constant of $C S_2$:—

t°C	φ	t°C	φ	t°C	φ
0	0·04300	10	0·04249	20	0·04186
1	0·04295	11	0·04244	21	0·04179
½	0·04290	12	0·04238	22	0·04172
3	0·04285	13	0·04232	23	0·04165
4	0·04281	14	0·04226	24	0·04158
5	0·04276	15	0·04220	25	0·04151
6	0·04271	16	0·04213	26	0·04143
7	0·04266	17	0·04207	27	0·04136
8	0·04261	18	0·04200	28	0·04128
9	0·04255	19	0·04193	29	0·04120

Resumé.

The amount of rotation obtainable from an optical ammeter or voltmeter varies as the square root of the weight of copper used in the winding when used most effectively. It also varies as the square root of the ratio of length to internal diameter of helix, so that the length should be as great as possible, and the internal diameter as small as possible, consistent with good optical conditions. There exists a practical limit to which the rotation obtained from any such instrument is subject, owing to the heat developed in the coil by the current. This limit is about 25deg., according to the estimates here given for currents of short duration, and 18deg. for instruments permanently in circuit. No theoretical limits are, however, prescribed if the thermal effects can be obviated. The best sizes of wire to employ for different instruments when the dimensions of the tube and weight of wire have been decided upon, are given in formulæ with examples, together with correction for virtual length, by which currents can be determined from good apparatus in absolute measure with an accuracy of at least one part in 750.

THE CENTRAL STATIONS OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.

BY DR. J. A. FLEMING.

The Metropolitan Electric Supply Company was formed in August, 1888, for the supply of electric energy from distributing and generating centres, and its work of establishing these centres in London has been pushed forward with great energy since that date. Under its Provisional Orders, this Corporation has assigned to it large and important areas of electric lighting in the Metropolis. These areas include in the aggregate more than 80 miles of streets, a large number of which run through some of the wealthiest portions of London. Under these circumstances, electrical engineers and the public generally will note with interest the progress being made in meeting the demand for electric lighting in these areas; and, by permission of the Directorate, we propose to give some description of the various central stations now actually in operation by this Company, taking them in order of completion.

Sardinia Street Station.

One of the largest of these, now completely finished and in active operation, is in Sardinia-street, Lincoln's Inn-fields. The erection of this station was begun in August, 1888, and

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on September 21, 1889, current was first supplied from it. The dynamo plant and engines were constructed by the Westinghouse Company, and it was arranged and fitted up by this last-named corporation in consultation with the engineering staff of the Metropolitan Electric Supply Company. The Sardinia-street station is a very complete and typical station for the supply of electric currents on the alternating-current transformer system. It consists of a substantial two-storey building, in the construction and design of which the highest possible architectural and engineering skill has been applied to cope with the difficulties which might arise from noise or vibration in a building so placed in the centre of a closely inhabited Metropolitan area. It may broadly be described as a box within a box; that is to say, the central portion, or machinery rooms, are enclosed in a building which is itself contained in a closed-in space; and the communication of aerial vibration is thus greatly limited by the double walls with intervening space which separate what may be called the vitals of the station from the external space. The communication of vibration through the foundations has been prevented by the most carefully arranged methods, and, generally speaking, the whole problem of installing a steam plant of the magnitude required in such a manner as to avoid the difficulties inherent in such a work, has been dealt with in a manner which speaks highly for the skill and experience invoked. The general plan of the station is shown in Figs. 1, 2 and 3. The chimney shaft is of white glazed brick externally, and the whole building is lined internally with white glazed brick, which gives it a very clean appearance. The ample space in the dynamo, engine, and boiler house render the working of the station most comfortable to the staff.

On the ground or entrance floor are placed the engines (*see* Fig. 3). The dynamos and exciters are on the floor above, and driven by belting passing up through the floor. The boiler-house is on a lower level than the engine-room, and the coal store is so arranged that the coal is shot down from the street level direct into it.

Entering on the engine-room level, which opens into a covered yard, we find a double row of Westinghouse compound engines. Five of these engines are each of 250 horse-power, and five are of a rather larger size, making in all a provision for the actual production of about 3,000 horse-power. Behind one series of these main engines stand

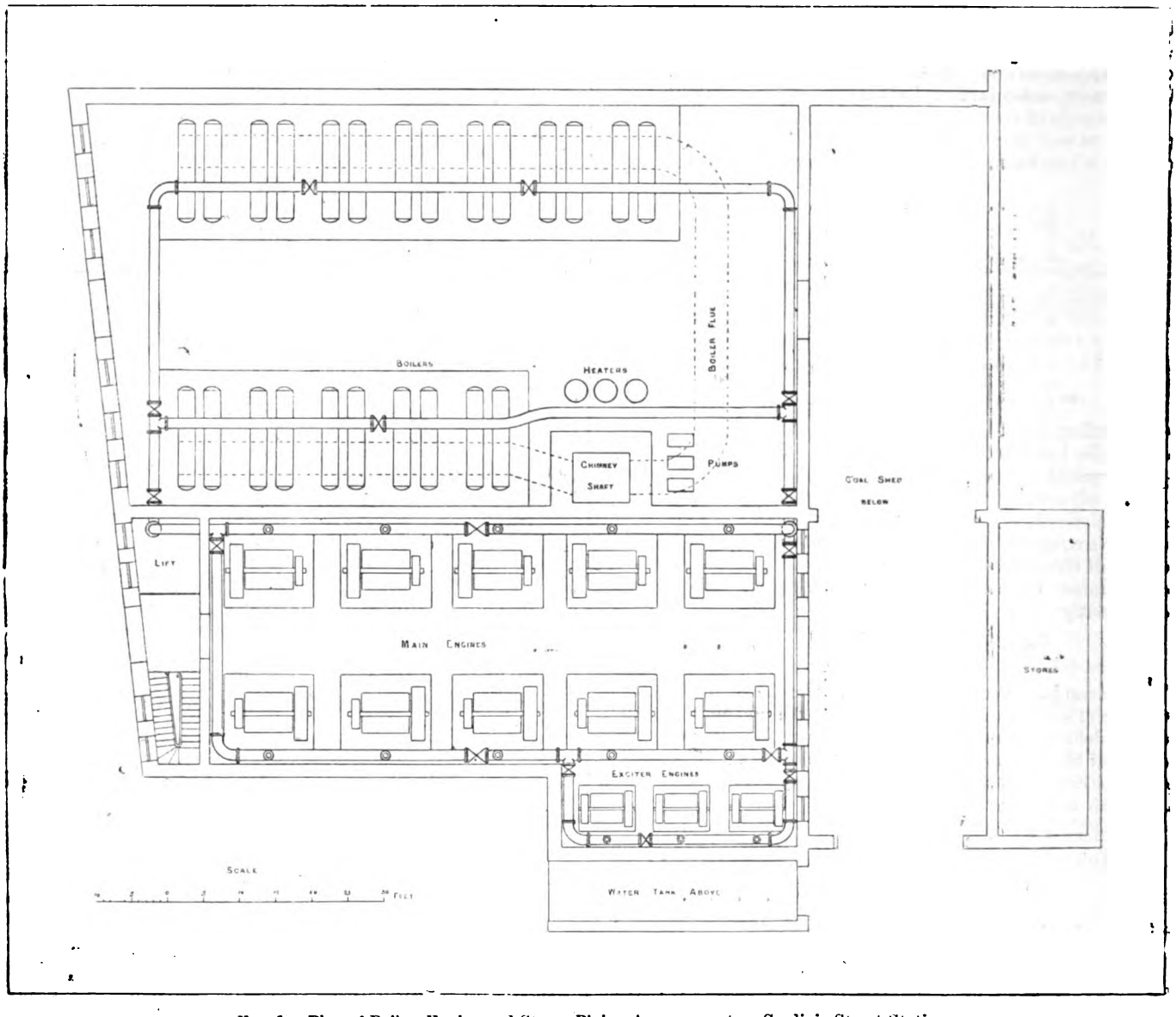

Fig. 1.—Plan of Boiler, Engine and Steam Piping Arrangements. Sardinia Street Station.

three Westinghouse engines of 65 horse-power, each of which serve to drive the exciter dynamos. The main engines have high-pressure cylinders of 14in. diameter, and low-pressure cylinders of 24in. diameter and 14in. stroke, and are technically known as 14 × 24 × 14 engines. The exciter engines have high-pressure cylinders of 10in. and low-pressure cylinders of 18in. and 10in. stroke. These Westinghouse engines are so well-known that space need not be occupied by detailed description of them. They are high-speed engines, making 200 revolutions per minute, and having a piston speed of 653ft. per minute. At Sardinia-street they are worked non-condensing. Each engine is built up on a brick and concrete platform which rests on a bed of felt and sheet lead, this in turn reposing on

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the concrete foundations. By this device the communication of "thump" through the foundations is prevented. This series of separate engines forms a steam plant, which can be divided up and operated in such a manner as to secure that the engines actually in use are being worked as nearly as possible at their full power. Each engine drives its own alternating current dynamo on the floor above by means of a leather belt. These belts are 20in. in width and made of the finest leather, spliced with bevelled joints to avoid any double thickness at a joint. The engines take steam from a ring steam main and exhaust into a single exhaust pipe large enough for 3,000 horse-power. Each section of the ring steam main can be isolated by stop valves, so that any section can be cut out without affecting the rest. Descending down one flight of steps into a lower level we find ourselves in the boiler-house, in which are erected 12 Babcock and Wilcox water-tube boilers, each capable of evaporating 6,000lb. of water per hour. These boilers are set in two rows face to face down the sides of the boiler-house, the length of the house being about 100ft. Ample space to stoke is left between the furnaces; and down the centre of the gangway runs a tram-line, on which the coal trolleys are run from the coal store to the furnace mouth. Underneath this gangway are the blow-off tanks and piping.

The boilers are supplied with water by three Worthington steam-pumps, any two of which will do the whole work; and the feed is so arranged that it can be taken either through the feed-water heaters, of which there are three, or by a by-pass direct into the boilers. The boilers are fed from both drums. The water tank is large enough for twelve hours' work at full load, and there is also a water supply direct from the mains. The boilers can be thus supplied either direct from the mains or from the water tank, though the water can be taken either through the feed-water heaters or direct into the boilers. The floor of the boiler-house is about eight or ten feet below the level of the street, so that dirt cannot be carried into the engine-room. The boiler-house has a glass sky-light roof, and is comfortable and spacious. At the end of the boiler-house is the coal store, capable of holding a month's supply of coal for the station when working at full load. Into this store the coals can be shot down from the coal carts in the street above by shoots. There it is handled into the coal trolleys and goes at once by the boiler-house tramway to be delivered at each ashpit. It is thus seen that the minimum of labour is required both in stoking and in coal handling. The boilers all feed their steam into a ring main, the general plan of the steam piping being shown in Fig. 1.

Ascending on to the first floor, above the engine room we find ourselves in a large and well-lighted dynamo room (*see* Fig. 2). Here are ten Westinghouse alternate-current dynamos, of 125 kilowatts out-put each, providing, therefore, for a total output of 1,250,000 watts, or for a supply of 20,000 50-watt lamps, all burning at one time. These dynamos are respectively driven by the belting coming up from the associated engine on the floor below. The belts and pulleys are covered in with belt shields. Each dynamo generates an alternating current at a pressure of about 1,050 volts when running at its normal speed of 1,030 revolutions per minute. These dynamos are technically known as the "No. 3" size. The dynamos are bolted down on strong wooden frames, and have the usual belt tighteners and screws. All moving parts of the dynamos are supplied with oil from sight-feed lubricators, which are themselves fed from an oil tank placed at a higher level. From this oil tank proceed a system of oil pipes to each dynamo. The waste oil runs away down-stairs by waste pipes; is cleaned, filtered, and pumped up again to the oil tank by a small pump. By this excellent arrangement, which

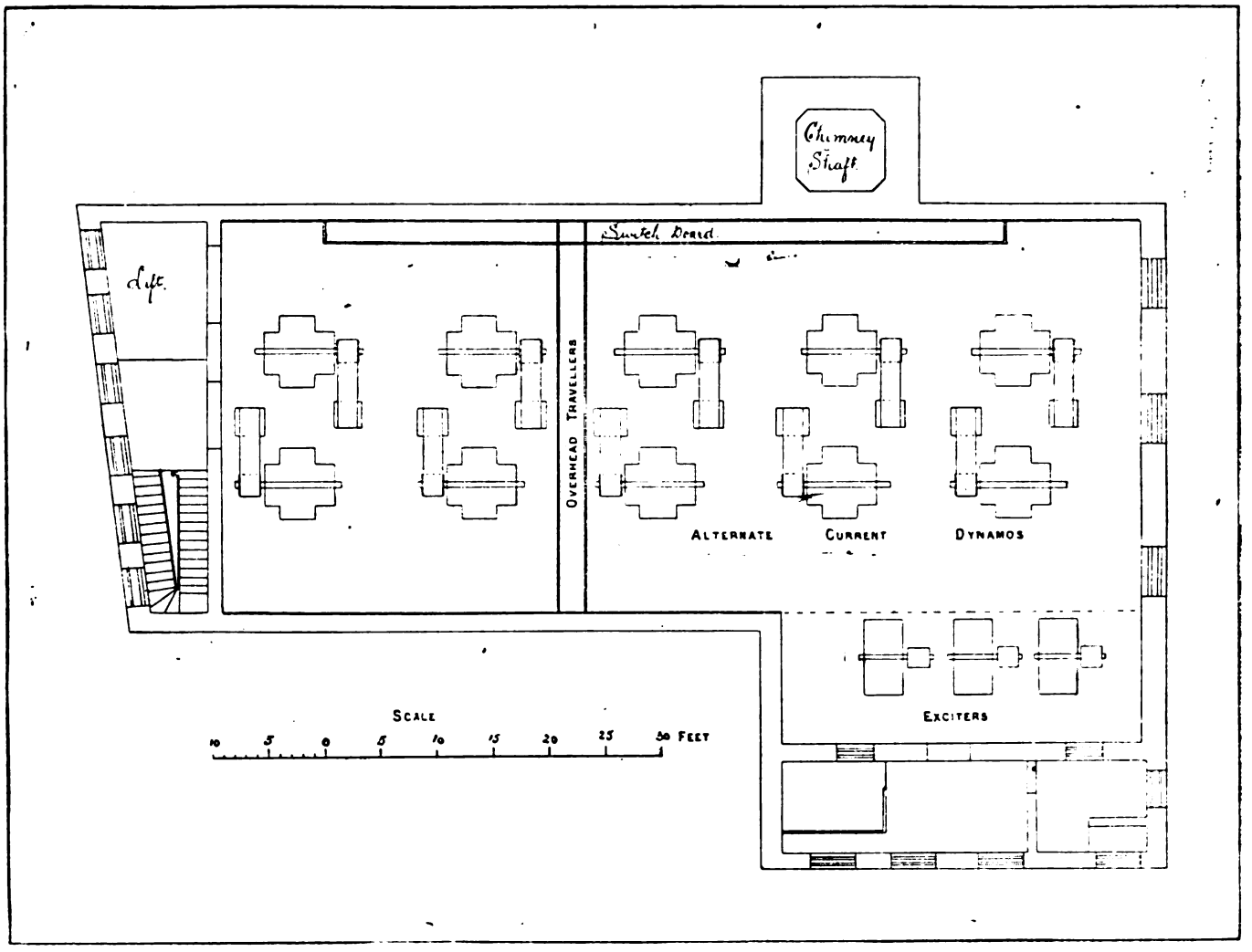

Fig. 2.—Plan of Dynamo Room. Sardinia Street Station.

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is characteristic of American engineering, the use of oil cans is rendered entirely unnecessary. The detailed description of this size and type of Westinghouse alternator

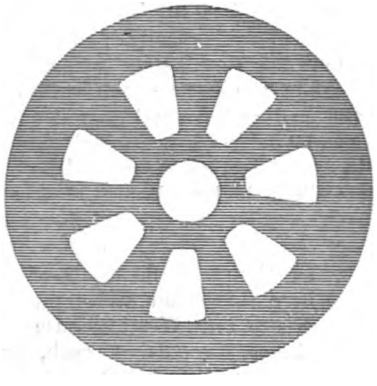

Fig. 4.—Sheet-Iron Disc of Westinghouse Armature Core.

has been given in *The Electrician* of October 3, 1890, p. 603. A few further details of its construction may here be given. The armature is composed of sheet-iron discs, which are punched out in the centre so as to leave wheel-shaped iron laminæ (*see* Fig. 4). These sheets are put together without paper between them; but previously, however, being slightly oxidised or rusted. It is found that the thin layer of oxide has sufficient electric non-conductivity to arrest eddy currents; but yet not any disadvantageous magnetic non-conductivity. These iron discs are assembled on the steel shaft, and compressed by massive screw-nuts between end plates. The soft-iron plates are carefully annealed after being punched, so as not to require touching with tools after this annealing. On this iron core is laid a layer of asbestos and mica, and then on this the flat, link-shaped coils of insulated wire. These coils consist of one layer of wire formed into a flat coil of 13 turns. Each coil is 27in. long in the straight part, 5·5in. wide; and the aperture of the coil, which is filled in with a wooden lathe, is 1in. wide (*see* Fig. 5). Hence there are $27 \times 26 = 702$in. of active wire on each coil. These coils are laid on the drum, and

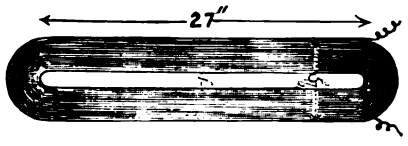

Fig. 5.—Single-Flat Coil of Westinghouse Armature.

are just so long that the curved ends of the coils can be bent over the end of the drum. Sixteen such coils are laid on, having one-quarter of an inch space, occupied by a wood strip, between adjacent coils. The coils are then bound on the drum with brass wire, the wire of the coils being protected by asbestos and mica insulation. The surface of the core is quite smooth, and the flat wire coils are kept in position and driven round simply by the friction due to the binding wire. The coils on each half of the drum are joined up in a series of eight, and the two series are joined together in parallel. Hence, each coil contributes 125 volts to the electromotive force, which is at the rate of less than six inches of wire to the volt. The wire of the armature coils is double cotton-covered and insulated with a special insulating varnish. The ends of the coils where they are turned over the flat end of the drum are defended by bronze shielding plates. The whole

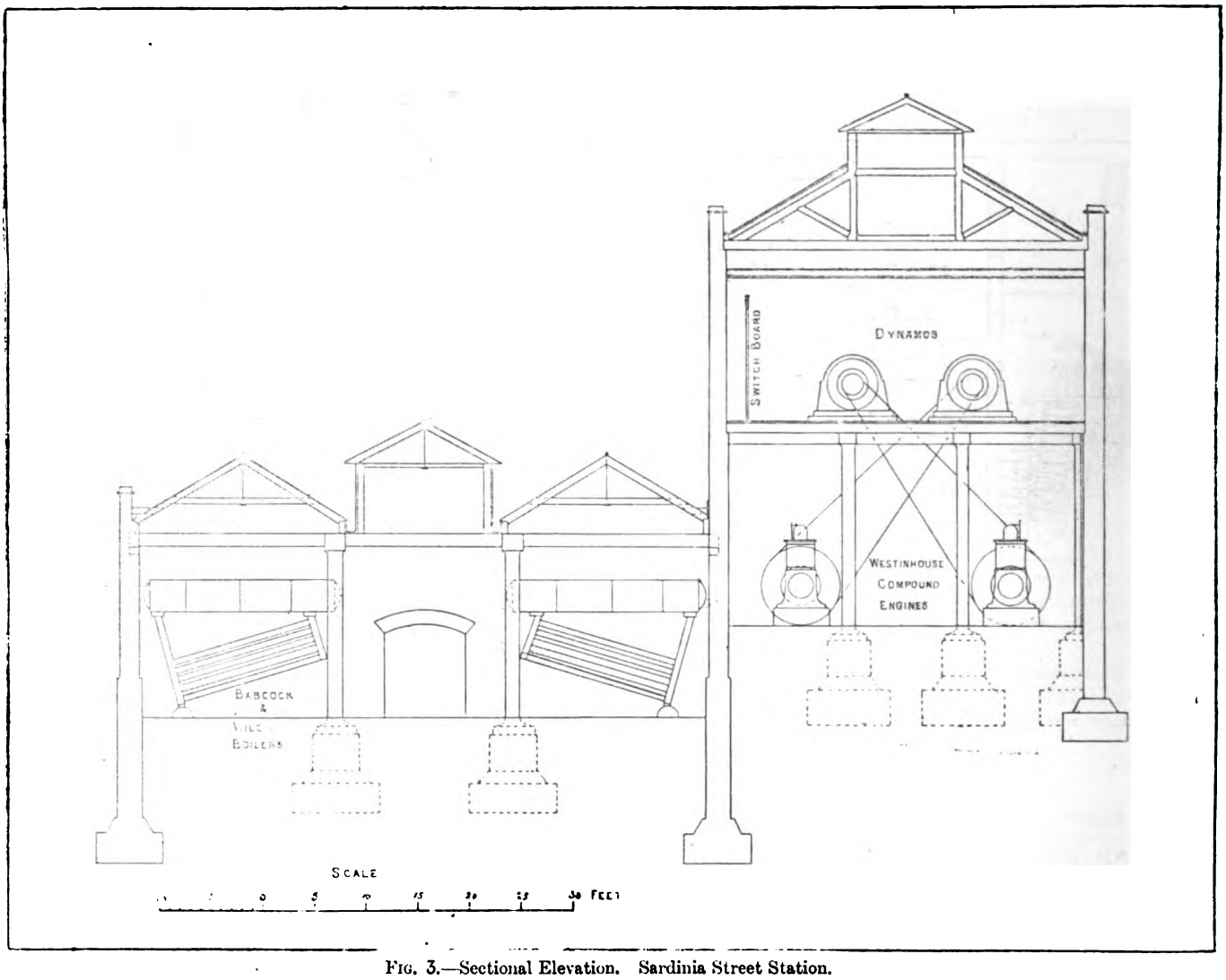

Fig. 3.—Sectional Elevation. Sardinia Street Station.

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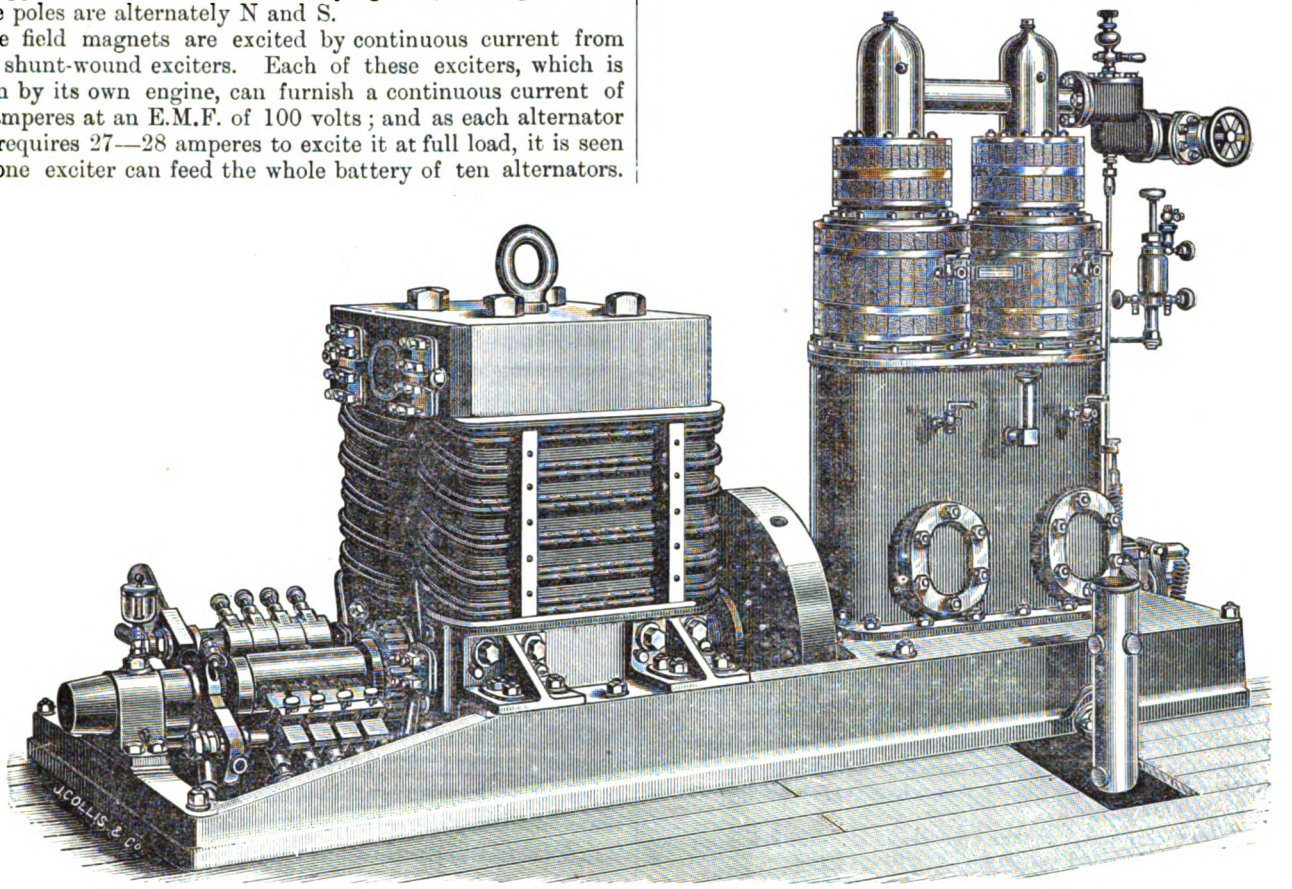
armature is thirty inches in diameter over all. In addition to the end plates another disc is provided at one end, with radial strips which act as a centrifugal fan and draw air through the apertures in the core to assist in keeping it cool.

The armatures of all the machines being exact facsimiles are interchangeable. By means of an overhead traveller, which runs the whole length of the dynamo-room, it is a matter of a few moments to lift off the top half of the field-magnet of any dynamo, lift its armature out of its bearings, and replace it by another. This construction of armature is both simple to repair, and admits of very high insulation being attained in practice. The ring-shaped field-magnet frames carry sixteen magnet poles projecting inwards. These poles are solid cast iron, and are 27in. long, 2·5 wide, and 8in. long. On to these poles are slipped the shells or frames carrying the field-magnet coils. These poles are alternately N and S.

The field magnets are excited by continuous current from three shunt-wound exciters. Each of these exciters, which is driven by its own engine, can furnish a continuous current of 300 amperes at an E.M.F. of 100 volts; and as each alternator only requires 27—28 amperes to excite it at full load, it is seen that one exciter can feed the whole battery of ten alternators.



Edison-Hopkinson Fifty-Three Kilowatt Dynamo and Willan's Central Valve Engine.

The exciters are ordinary horizontal double-magnet shunt-wound continuous-current machines. They have pulleys with paper driving surface, and are the usual form of Westinghouse exciters.

From these exciters leads run to the switch-board, to be described in another article, at which all combinations and interchanges are effected.

(To be continued.)

EFFICIENCY OF THE EDISON-HOPKINSON DYNAMO AND WILLAN'S CENTRAL VALVE ENGINE.

Various tests have been published from time to time of the efficiency of Messrs. Willan's and Robinson's Central Valve Engine, and the several types of dynamos with which they are combined. At a recent test made at Thames Ditton with a large Edison-Hopkinson dynamo, constructed by Messrs. Mather and Platt, of the Salford Ironworks, Manchester, a result has been obtained giving an efficiency superior to anything previously attained. The results show an efficiency of engine and dynamo combined, *i.e.*, the ratio of the electrical power available for useful work outside the dynamo to the indicated power of the engine, of 86·7 per cent.

The following are particulars of the engine and dynamo, shown in the accompanying illustration: — Compound double crank engine with low pressure cylinders 14in. diameter, stroke 6in., to work with 120lb. steam pressure, driving direct an Edison-Hopkinson dynamo, constructed for an output of 110 volts 475 amperes at 430 revolutions per minute. The dynamo has a bar armature, and is shunt-wound only. It is fitted with a commutator of hard drawn copper with mica insulation, with four brushes on each rocking arm. The resistance of the magnets is 16 ohms and that of the armature 0·0055 ohm. The indicated horse-power of the engine was 83·3, and the useful electrical horse-power given out by the dynamo was 72·2 Hence the efficiency was 86·7 per cent. The consumption of water per indicated horse-power was 21·6lb The consumption of water per electrical horse-power was 25lb.

In the test made on this combination both engine and dynamo were worked to a somewhat higher load than their normal or specified load, and this, no doubt, would be to a slight extent favourable to the efficiency. Another test was made on a similar combination working at its normal load, with the following results:—Resistance of armature, 0·0058 ohm; resistance of magnets, 15·6 ohms; indicated horse-power, 85·3; electrical horse-power, 70·0. Efficiency, 83·3 per cent.

The electrical losses in the first instance are:—Loss in magnet coils, 756 watts = 1·4 per cent.; loss in armature coils, 1,386 watts = 2·6 per cent. Electrical efficiency = 96·0 per cent. From this it follows that the loss in friction in the engine and dynamo combined is 10 per cent. of the indicated horse-power.

Messrs. Mather and Platt have constructed a large number of dynamos for combination with the Willan's engine. Those referred to above are part of a number constructed to the order of Mr. Hargreaves for the City installation of Messrs. Spiers and Pond. Others of a considerably larger output are in progress for Messrs. Gatti's central station in the Strand, and for the Westminster Electric Supply Corporation's installations.

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The Electrician.

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SUBWAYS FOR SUPPLY MAINS.

The formidable opposition which was brought to bear last Session, upon the Subway and Overhead Wires Bill of the London County Council resulted, as our readers will remember, in its ultimate rejection; in spite of the fact that by the time that the Bill received its quietus its scope had been much curtailed, thanks to the petition of the Kensington Company which has pioneered the making of conduits in our streets. At present it appears that the municipal control of electric mains is limited to the general assent of the Local Authority to the Provisional Order of the supply company, and to the specific consent which is given from time to time to the notice of intention to lay mains in certain streets. The Board of Trade prescribes the conditions under which conductors are to be laid, and defines the state of efficiency as which they are to be maintained, besides giving rules as to the construction of conduits in the regulations which are now issued with Electric Lighting Orders. The *canalization*, as it is called in France, has therefore been taken in hand and controlled by one of the most paternally disposed departments of the Government; and it does not appear why the County Council need trouble themselves about it. A system of subways has a fascinating air of completeness, and, to the municipal mind, it appears to possess the additional attraction of affording a possible means of "relieving the rates." If it were only proposed to make such a charge as would pay for the interest on the cost of such subways, and for their maintenance, there would be less injustice in the scheme; but, it must also be remembered that if the supply companies make a success of their business, their property will surely be taken over by the Local Authorities in forty-two years, or earlier; and by that

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time they would have more than repaid their share of the cost of the subways. It seems to us, however, that the Metropolis is not altogether a suitable place for an elaborate system of subways, although there are some short lengths in existence at present, since, in the construction of several of the important thoroughfares, opportunity has been taken to construct subways which have up till now been but little used. It is true that electric mains could be placed thus under constant supervision, and it would be easy to obtain access to any part of them; but it is part of the scheme that they should be laid side by side with gas and water mains, and these are quite as apt to leak, and, unlike electric mains, are liable to burst. They will, therefore, much more probably damage the electric mains than be damaged by them. That the present gas mains leak to a considerable extent is evident whenever the streets are opened. In the absence of any Board of Trade regulations as to leakage, some companies seem to rely on the pressure of the surrounding soil to keep their joints tight, and the escape of a million feet or so does not affect them much. A leak of gas in a subway would, however, be a very different matter, and it is impossible to estimate the damage which would be caused in such a case by an explosion, such as that which occurred at Streatham last week, or the probable effect on the electric mains of the bursting of a high-pressure hydraulic power main in a confined tunnel. It seems that both gas and water pipes are best left where they are. The inconvenience of the present arrangement is chiefly that of the obstruction of the traffic when alterations or repairs are necessary. The conveniences of the subway system may have to be compared with the possible destruction of life and property.

It is not always easy to impose conditions on already existing institutions, but any difficulty there may be fades into nothing by the side of the gigantic task of undertaking and completing such a feat of engineering, and then compelling the various supply companies to make use of it. The mere tunnelling under the main thoroughfares would be serious enough; but it was proposed to re-lay within the subway all service mains for gas, water, and electricity, and possibly for compressed air and steam. The existing distribution would be disorganized at an immense cost and inconvenience to the public. The question may well be raised as to the fitness of any corporate body, the members of which are continually changing, to undertake a work of this magnitude, not only on account of the changes which are likely to take place in the administration of it when complete, but of the unity of plan which is necessary during the execution of the work. The great works of antiquity that by reason of their public convenience bear some analogy to the one under consideration, the immense aqueducts constructed by the Roman Emperors were begun and carried out to a successful termination by one master-hand, who supplied the element of continuity of supervision which is essential for such undertakings. We have misgivings as to a municipal system of subways, until the County Council prove that they are able to carry out important works, and show more appreciation for the services of engineers who are able to design and execute them.

Another difficulty of scarcely less magnitude is that of finance. To ensure that the roadways shall be free from future disturbance—and this is after all the main object—it will be necessary that the subways be well designed, well constructed, and large enough to accommodate any reasonable future increase in the demand for their use. All this needs money. We have some recent American estimates, which, though no more valuable as a guide than are most American figures, since their prices and requirements differ so largely from our own—may be taken at all events as a guide to the difficulty of the task. We ought then, perhaps, scarcely to be surprised to find that the cost is calculated at £89,000 per mile. Still, in spite of this heavy expenditure, certain members of the County Council have it in their minds to do a good stroke of business, and actually relieve the rates by charging a heavy rental from those whom they propose to compel to use the subways. Some conception of the rentals that might be charged may be gained from those at present asked in New York, where the preposterous sum of £200 per mile per annum is demanded for a three-inch duct. A rental of anything like this description would heavily tax electric supply companies, who are already sufficiently handicapped in their competition with gas.

At the present time, several electric lighting companies have made arrangements with the railway companies to lay their mains along the cuttings, tunnels, and bridges. The conductors so placed are readily accessible by authorized persons, and are not likely to be interfered with by others. They can be placed thus at a less expense than in any other manner, and the arrangement has already been found to be very advantageous and satisfactory. There was a question or two as to the price charged by the railway companies for this accommodation at the Board of Trade enquiry, but the supply companies did not care to disclose their bargains. They would doubtless take advantage of subways if they could be used at a fair rental; but the only method by which such a rental could be judged, from the supply companies' point of view, would be to compare it with the cost of making and maintaining a conduit, or other method of laying their mains. Those who are content to lay an armoured cable immediately below the foot pavement would not care to pay much for the use of a subway, while others who construct carefully-built and cemented conduits, and put down bare copper strips with numerous insulators, straining gear and manholes, might be more inclined to give the matter their consideration. Such companies are sinking a good deal of their capital in their conduits and mains, and this capital cannot for some time be considered as producing a fair return; for a conduit has to be constructed, not for the supply of to-morrow, but to take the conductors that will probably be required hereafter, when present leases have run out and more houses are wired. The conductors, too, are heavier in most districts than are needed for the present demands, and although the generating plant may be added to, the distributing mains will be an incubus for the first few years, and the expenses connected with them must reduce, if not extinguish, dividends until the demand has increased sufficiently to utilise them more fully.

The cost of generating a unit of electrical energy is now pretty well known, but the cost of distributing it to the consumers' terminals is very difficult to estimate, depending as it does upon the cost of laying the mains and the extent to which they are employed. It would be, therefore, no easy matter to estimate the value of the accommodation offered by a subway for a new main, and if a high charge were made it would merely be taxing the consumers of electricity for the convenience of the public who use the streets. The suggestion that supply companies should at their own expense re-lay their mains and pipes in subways to be constructed by the Local Authority but to be paid for by the users, is too wild an idea for serious consideration. Now that a thoroughly experienced and reliable business man is Chairman of the County Council it is, we hope, less likely that such a proposal will be made again.

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ELECTRICAL DISTRIBUTION BY TRANSFORMERS FROM CENTRAL AND ECCENTRIC STATIONS.*

BY DR. J. A. FLEMING, M.A.

(Continued from page 679.)

§ 15. **Typical Westinghouse Transformer Stations.**—One of the largest stations for the supply of electric current by the Westinghouse transformer system is at Pittsburgh, Pa., in the United States. The boilers at this station are of the water-tube type, heated by natural gas. The engines are of the well-known standard Westinghouse engines, and stand on square blocks of concrete or masonry, the blocks for the size used, burgh is about 9ft. high and 14ft. long, and stands away from the wall of the dynamo room about 3ft. to enable access to be had behind it for making all connections.

One single exciter dynamo is used, another being in reserve, to provide exciting current for several machines, and convenient switches are placed on the board to enable the excitation to be effected by either of the exciters. The general details of the board, as well as the arrangements for measuring and regulating the pressure at the far end of each feeder, have been already described. This station furnishes current for about 13,000 incandescent lamps (1890).

A very typical Westinghouse station, operating overhead primary conductors, is that at East Liberty, Pa., U.S.A. The service from this station covers a very extended area, com-

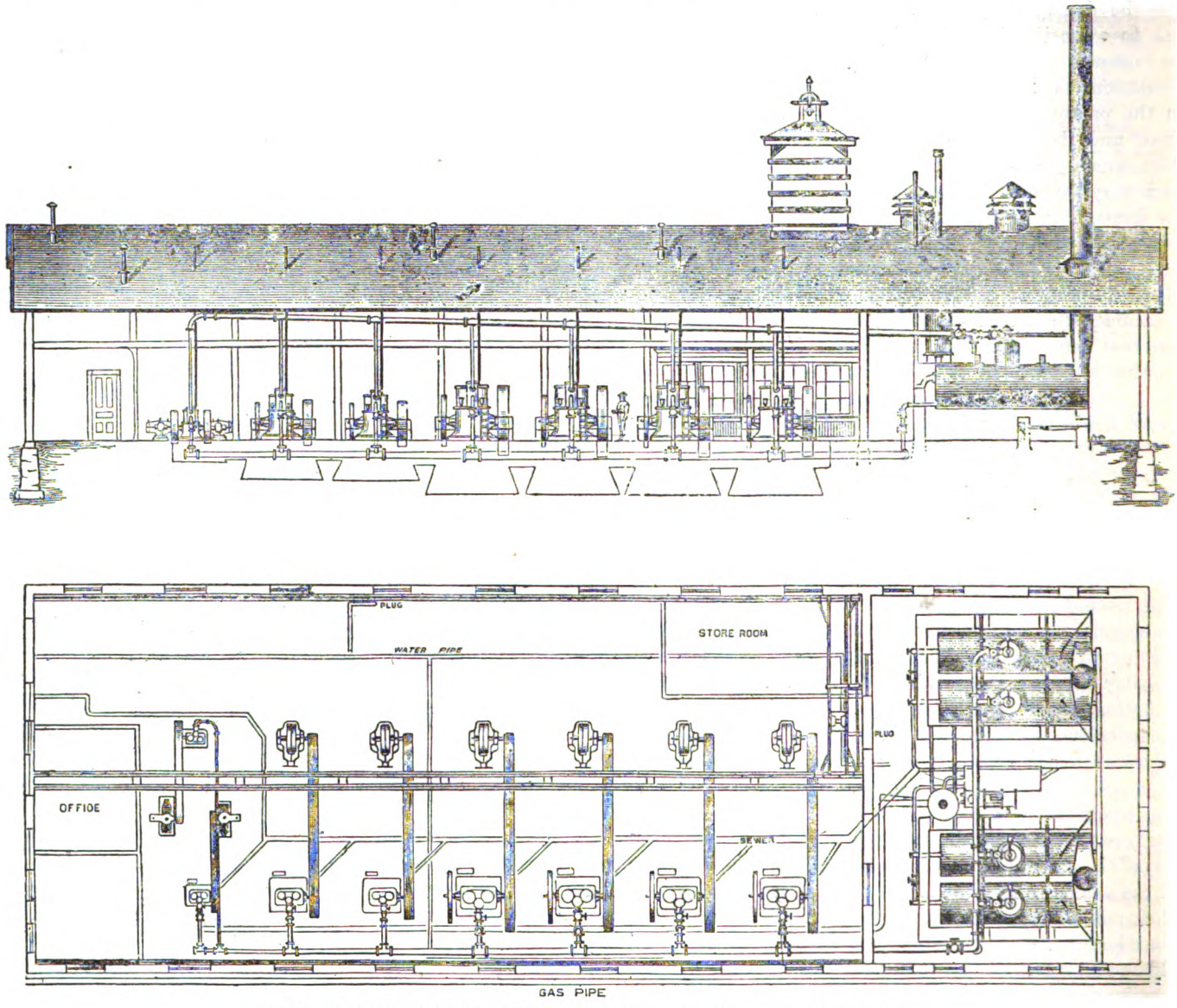

Fig. 47.—Elevation and Plan of Westinghouse Central Station at East Liberty, Pa.

250 horse-power, being about 7ft. by 5ft. Five of these engines drive five alternating current dynamos, each having a capacity for 2,500 16 candle-power incandescent lamps. Besides this there is a Corliss engine, driving another dynamo. The exciters are driven from separate smaller engines. The engines driving the alternating dynamos make 250 revolutions per minute, and the dynamos 1,050. The power of the engines is conveyed to the dynamos, which are placed on a floor above, by belts. Each dynamo is fixed on a sliding bed, so that the belt can be tightened. The general construction of these alternators has been described in a previous section. From the dynamos the mains are run to the switch-board in troughs cut in the joists supporting the floor. The switch-board at Pitts-

prising the business portion of the city, which lies at an average distance of half a mile from the station, ramifying through an extended series of residence streets, and carrying a special line to a distant suburb in which the last lamp is four-and-a-quarter miles from the dynamo. The arrangement of the building is shown in Fig. 47. A one-storied brick building contains offices, stores, dynamos, and boiler room. The plant has an aggregate capacity of about 8,000 lights. Dynamos and engines are on the same floor, every part of which is under the eye of a single attendant. The engines and dynamos stand on brick foundations. Each engine is belted to its own dynamo. The steam pipe is brought along overhead, and the engines exhaust into a main laid in a covered trench underneath the floor. Two exciters are provided as shown on the left of the dynamo room,

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each adequate to supply current to the entire station, and each driven independently by its own engine. Only one exciter and engine is operated at once. The position of the exciters and engines is such that by changing a belt either engine can drive

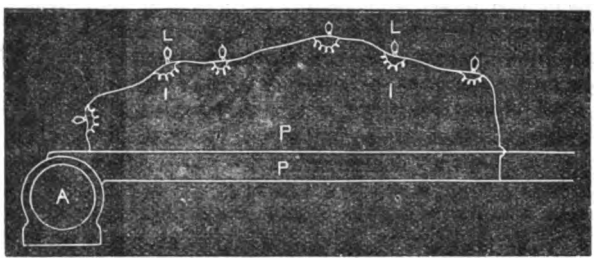

FIG. 48.

either exciter. Two overhead cranes traverse the whole length of the buildings over the engines and dynamos. Using natural gas to fire the boilers, attendance is reduced to a minimum, and one attendant in the dynamo room can give

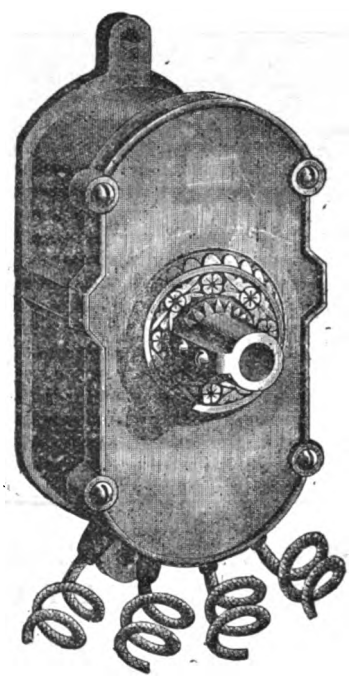

FIG. 49.—Westinghouse Impedance Coil for Series Lighting.

all necessary attention to the engines, dynamos, exciters, and switch-board. The reduction of labour to a minimum is especially made an object in the design of these American stations.

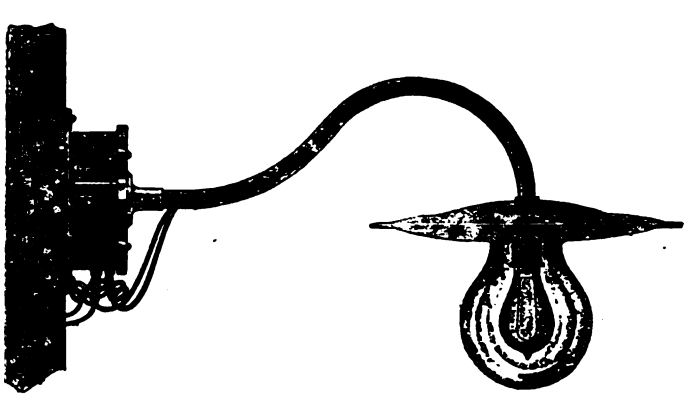

FIG. 50.—Series Street Lamp and Impedance Coil.

In connection with these transformer stations, a system of street incandescent lighting has been worked out, which is very efficient, and enables a large amount of street lighting over scattered areas to be taken up, but which would not be remunerative if primary mains and transformers had to be placed along the whole route. Starting anywhere from one primary main or feeder, P (*see* Fig. 48), a single line is run following the route of the proposed street lighting; and at every place where a street light, L, is required, an impedance or choking coil, I, is placed having a low-resistance series incandescent lamp across its terminals. This line is then so run that it terminates at some distant spot on the other member of that same primary line or feeder. Suppose that the primary pressure is 1,000 volts, and that 10 volt low-resistance lamps are used, there can be 100 such coils and lamps on that series line. The impedance coil is contained in a box on the bracket that carries the lamp (*see* Figs. 49, 50). If any lamp breaks, the impedance coil is thereby thrown into the circuit and lowers the current just by that amount which keeps the rest of the lamps on that circuit from being over burnt. Hence the breakage of any of the lamps does not affect the light of the rest, nor does the removal of one lamp in any way affect the operation of the others, although the lamps are all in series.

(To be continued.)

SIR WILLIAM THOMSON'S NEW ELECTRICITY METER.

This supply meter, which was exhibited and described before Section G at the recent meeting of the British Association, records on a train of counting wheels the amount of current which has passed through it during any given time; and forms, also, an indicator by which the strength of current passing at any given instant can be read off on a scale.

The indicator consists of a light aluminium girder, free to turn about a horizontal axis, having at its top end a flat coil of fine copper wire, *c* (Fig. 1), and at its lower extremity a train of counting wheels, ω (Fig. 2). The frame is supported on knife-edges, and a current is conducted into and out of the fine wire coil by two spirals of fine copper wire. The resistance of this coil is about 30 ohms, and it is joined in series with an anti-inductive platinoid resistance, R, of 970 ohms. When the meter is in action a small current is kept passing through the circuit. The whole current to be measured is conducted through a fixed coil, C (Fig. 1), of copper ribbon, which is placed with its plane parallel to the plane of the fine wire coil when the latter is in its zero position. A scale, S (Fig. 1), divided to give readings in amperes, is attached to the indicator, on which the strength of current passing through the fixed coil can be read off by means of an index fixed to the case of the instrument.

The recording apparatus consists of the train of counting wheels ω, with a plain rolling wheel on the first arbor, and a revolving cam or barrel, K, driven by clockwork, which is kept in motion by a weight, W. The cam is kept revolving at a uniform rate, and, when a current is passing through the instrument, at each revolution it lifts up the trailing wheel on the first arbor of the counting train, which it causes to turn round, and so makes a record.

The profile of this cam is diagrammatically indicated in Fig. 1 by a slanting line; but is more clearly shown in Fig. 3, and its surface is shown unrolled or developed in Fig. 4. The curved line of its edge is, in fact, the curve giving the law of repulsion of the light shunt coil by the fixed main coil. The driving gear is controlled by a centrifugal governor shown below the cam (Figs. 1 and 2), giving a continuous rotation of the cam once in six minutes.

The action of the meter may be shortly stated as follows:—When no current is passing the indicator stands at zero on the scale, S, the movable coil being about one millimetre from the fixed one, and the trailing-wheel on the counter-train being quite clear of the cam, so that no record can possibly be made. When a current is passing through the fixed coil the top end of the indicator is repelled *outwards*, and the counting-train of wheels is brought *inwards* towards the cam to a position depending upon the strength of current which can be read

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off on the scale. In this position, at the proper time of revolution, the trailing-wheel is lifted by the cam, and runs over a shorter or longer path in proportion to the strength of current. For small currents, the trailing wheel rolls on the barrel surface of the cam for only a short period during each revolution; but, with heavier loads, it travels over a path of considerable length. Thus, if the current passing through the fixed coil be 5 amperes, the counting-wheels might record 20 for every revolution of the cam; whereas, were the current 10 amperes, the trailing-wheel would roll over twice as long a path, and the record would be 40. Any slight inaccuracy in the parallelism of the axes of the trailing wheel and of the cam would cause

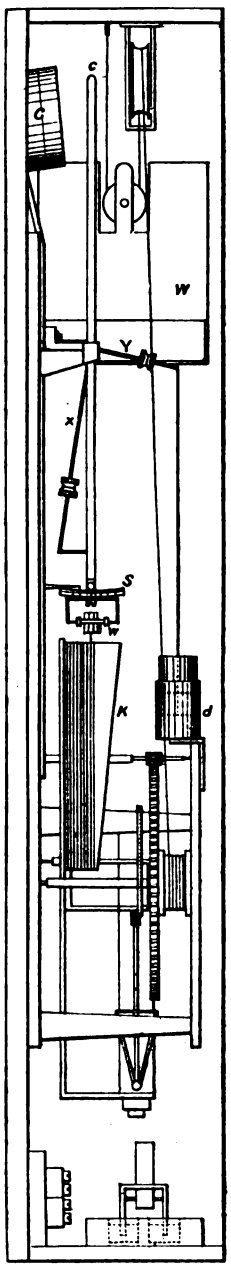

Fig. 1.—Side View.

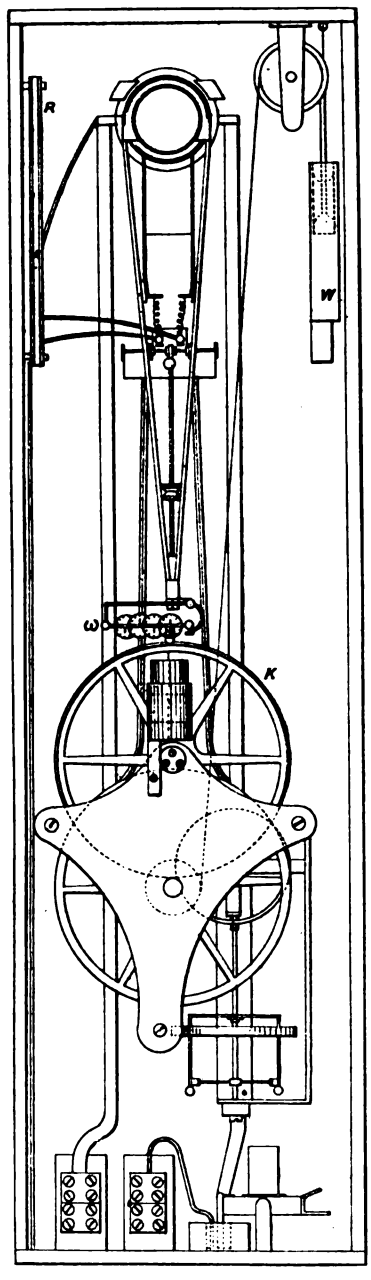

Fig. 2.—Front View.

the former to describe a helical path on the cam. To avoid this, the surface is cut into fine grooves on the part corresponding to the higher readings, and in one or other of these the trailing wheel runs. These grooves are much more numerous than are shown in Fig. 3, where the trailing wheel is shown running in the second one. The part of the cam corresponding to the lower ranges is left smooth, as it has been found easy to adjust the counter to record correctly throughout the most sensitive portions of its range.

Two screwed rods are so attached to the indicator, that one, x (Fig. 1), is vertical, and the other, y, is horizontal, when the beam is in its zero position. These rods are provided with adjustable nuts, those on the vertical being to adjust the sensibility of the instrument, while those on the horizontal rod are for the adjustment of the zero. By means of the former the constant of the meter can be quickly varied if found convenient. Thus a meter which is suitable for measurement from 1 to 20 lamps can be altered in a few minutes to suit ranges of from

Fig. 3.—Side View of Cam.

1 to 50 or from 1 to 100 lamps. This adjustment can be made by an inspector, without the use of any auxiliary instrument. All that has to be done is to hang on a weight of a given amount on the knife-edge stirrup at the end of the horizontal arm, and raise or lower the nuts on the vertical arm till the indicator shows a given reading on its scale. By this means also the constant of the meter can be checked at any time.

Fig. 4.—Development of Cam $\frac{1}{10}$ Full Size.

As at present arranged the driving weight requires to be wound up periodically by means of a revolving disc on the front of the case. It is intended that this should be done by the consumer, and an arrangement is made by which the current is automatically cut off from the house when the weight is allowed to run down. Several very ingenious precautions are also taken to prevent any fraudulent tampering with the instrument.

ON THE ELECTROSTATIC FORCE BETWEEN CONDUCTORS CONVEYING STEADY OR TRANSIENT CURRENTS.*

BY DR. OLIVER LODGE.

At the last meeting of the Physical Society this session Mr. Boys described some attempts he had made to detect mechanical force between a pair of Hertz resonators delicately suspended and immersed in a region of electro-magnetic waves.

The attempt, so far, had not been successful; but Mr. Boys, by attending to the energy manifested by Mr. Gregory's method and by another method of his own, showed good reason why the force, if any, was just too small to be observed, even with his extremely delicate appliances, and conjectured that a moderate increase in sensitiveness would be necessary in order to detect the effect. Everyone must have full confidence that if any such mechanical effect exists Mr. Boys will show it us before long; but, in common with Prof. Fitzgerald, I feel provisionally and tentatively doubtful whether any mechanical effect really exists between electric pulses travelling along wires with the velocity of light. In a wire subject to electric stationary waves, there are obvious electrostatic pulses at either end, and electrokinetic pulses at the middle; but Mr. Boys had alloyed for all that, and arranged that the opposing effects of ends and middle should conspire to assist each other in causing rotation. What I felt doubtful about was, whether, even in infinite wires, wherein all complication by reflection and stationary waves was avoided, a pair of pulses travelling side by side, like a pair of humps (or a hump and a hollow) on a pair of parallel cords, would exert any force on each other. It

* Abstract of a Paper read before the British Association, in Section A, Leeds, September, 1890.

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is known that two charged bodies flying side by side with the velocity of light will exert no such effect (Mr. Heaviside has shown that this is equivalent to saying that two elements in the same wave-front exert no mechanical force on each other); but whether the same thing is true of two wire-conducted pulses has not, as far as I know, been examined by mathematicians.

If it should turn out that pulses at full speed have no effect, then two straight oscillators in similar phases should repel each other, by the electrostatic effect of the slackening and stationary pulses which are being reflected at the ends.

Such an action seems optically rather interesting. Maxwell predicted that a reflector or absorber would be repelled by light; though, as we know, the complication of the more vigorous molecular action of material surroundings prevented Mr. Crookes from detecting this precise effect. We know, however, that it must exist; and the repulsive effects between alternating magnets and copper discs, detected by Faraday and recently made much of in an interesting manner by Prof. Elihu Thomson, are examples of this very thing. We can even say what the stress caused by full sunshine ought to be, viz, about 50 microbarads*—that is, the weight of half a milligramme per square metre; but it has not yet been experimentally observed. If Mr. Boys finds his effect, at least if he finds it in the form I suggest, as an overbalancing static repulsion, it will represent an action between two sources of light or between two similarly illuminated bodies.

First, consider the action of currents in general on each other, and find the ratio between their electrostatic and electrokinetic forces. So far as I know, the electrostatic force between two steady currents is usually overlooked.

No advantage in generality is gained by treating two separate circuits, a movable portion arranged near a fixed portion of one and the same circuit is sufficient.

Steady Currents.—With steady currents the ratio of the static attraction to the magnetic repulsion is on every possible system of units a pure number.

To get a notion of its value, suppose the wires to be round and of radius ρ, the distance between them a; then the capacity per unit length of the two conductors is

$$S_1 = K/4 \log \frac{a}{\rho};$$

and since

$$\frac{1}{\mu K} = (\text{the velocity of light})^2 = \left(\frac{30 \text{ ohms}}{\mu}\right)^2,$$

the above-mentioned numerical ratio is

$$\frac{F}{F_1} = \frac{S_1^2 R^2}{\mu K} = \left(\frac{\text{number of ohms in the wire R}}{120 \log \frac{a}{\rho}}\right)^2.$$

Suppose, for instance, the wires were 50 diameters apart, or $4 \log a/\rho = 18{\cdot}4$, the two forces would be equal, and just balance each other, if R was 552 ohms.

With any resistance greater than this the electrostatic force would have the advantage, and two opposite currents in the given wires would *attract*.

Transient Currents.—Proceeding to consider the transient current of a Leyden jar discharge round the same circuit, unless the waves are much shorter than usual, the ultimate effect on a short length will be very little different from the effect of a uniform potential alternating sinuously in time, the difference of potential at any instant between the fixed and movable wire being

$$V = P C,$$

where P is the impedance of the intervening portion of the circuit.

And the ratio of the two impulses is

$$\frac{\phi}{\phi'} = \frac{S_1^2 P^2}{\mu K}$$

Taking as an example the same round wire conductor as before, with

$$S_1 = \frac{K}{4 \log \frac{a}{\rho}}, = \frac{K}{18{\cdot}4} \text{ say,}$$

and considering $\frac{L}{L_0}$ as $\left(\frac{18{\cdot}4}{20}\right)^2$, for instance, the two impulses will be equal and just balance each other if the length representing L on the magnetic system of units be 400 times as great as the length representing S on the electrostatic system. Any wire longer than this gives attraction the advantage; any wire shorter than this favours repulsion.

Or, with different jars discharging round a given circuit, small jars will exhibit the electrostatic impulse, big ones the electrokinetic.

Illustrating numerically still further: A length of 30 metres of No. 16 copper wire opened out into a single large loop has a self-induction of 500 "metres," or 50 micro-secohms. Using this as the wire R between the two suspended conductors, the critical-sized Leyden jar which should excite no force when discharged through them is about $1\frac{1}{4}$ "metres," or ·00014 microfarad; *i.e.*, smaller than the ordinary "pint" size.

With the help of an adjustable condenser, an instrument for measuring the L of well-insulated coils free from iron suggests itself here.

Measure of "v."—In applying an experimental observation of this kind to a determination of the product of the ether constants μ, K, (and it just strikes me that it is after all only a modification of the method by which Maxwell himself made one of the early determinations), is will be better to use round wires rather than strips, because linear dimensions then come in only under a logarithm, and, moreover, are such as can be measured with considerable accuracy without difficulty. Some of Mr. Boys' quartz-fibre and aluminium-tube devices ought to permit the zero of force to be sharply got, and thus a good measure of v to be made.

We should have to observe very exactly the neutralisation of all force between the suspended and fixed conductors while a steady current was passing through them, with an interposed wire of known resistance, and then use the relation

$$\mu K = S_1^2 R^2,$$

or

$$v = \frac{S_1}{K} \frac{R}{\mu} = \frac{\text{resistance of wire expressed as a velocity}}{4 \log \frac{a}{\rho}}$$

By filling the vessel containing the acting conductors with other insulating media, it is possible that the v for them could be directly measured.

Action of Moving Charges and Pulses.—If, by reflection at distant unjoined ends of an open circuit, the pulses be turned from progressive into stationary waves, then localities can be found on the wires at which attraction or repulsion permanently occurs; the sinuous distribution of current lags a quarter period behind the sinuous distribution of charge. Hence, at a given instant, there will be places where the current force is a maximum and the static force zero; while at a quarter wave-length on either side, the current force is zero and the static force a maximum. Half-way between these places only will the two forces be equal, but with alternate agreement and disagreement of sign. A readjustment of phase between the conductors will now make all the difference; a shift of a quarter wave-length changing from maximum to zero, and a shift of half a wave-length bringing about reversal of sign.

According to all this, therefore (if it be correct), it follows that the simple ideas on which Mr. Boys set to work are right after all, and that he will detect the forces in the way he expects.

Variation with Distance.—A few words as to the magnitude of the effect to be expected. Hertz has shown (*see* "Nature," vol. XXXIX., p. 404) that, at a reasonable distance from a rectilinear oscillator, one or two wave-lengths being practically sufficient, the electric force (or electromotive intensity) is per-

* Langley's recent estimate, that a square centimetre fully exposed to sunshine receives 2·34 C.G.S. thermal units per minute, is equivalent to an energy of 67 ergs per cubic metre of sunshine, or 67 microbarads. (A "barad" means an erg per cubic centimetre, or a dyne per square centimetre.)

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pendicular to the radius vector from middle of oscillator, and is of magnitude

$$E = \frac{Q l q^2}{K \rho} \cdot \sin(q\rho - pt) \cdot \sin\theta ;$$

where ρ and θ are the polar co-ordinates of the place, and $q = 2\pi/\lambda$.

To get an idea of the magnitude of this intensity at any considerable distance from the axis, write $Q = S V$, where V_0 is measured by the length of spark employed at the oscillator, and write for q^2 its value $\frac{\mu K}{L S}$; then the amplitude of the electric force reduces to

$$E = \frac{V \sin^2\theta}{2rc},$$

when an approximate value for L is substituted. Take as a numerical example any convenient oscillator, say, the small oscillator drawn to scale on page 54 of the *Philosophical Magazine* for July, 1889, which emits waves 1 metre long; let its constant $c = 4\frac{1}{2}$, and its spark be, as there quoted, 8 millimetres, so that V_0 is about 26,000 volts. Then the initial electric intensity at a distance of a couple of wave-lengths in the equator is

$$E_0 = \frac{26000 \text{ volts}}{18 \text{ metres}}$$

$$= 14{\cdot}4 \text{ volts per centimetre.}$$

Putting therefore at this distance of 2 metres a parallel wire half a wave-length long as receiver, it utilises 50 centimetres of the above electromotive force, and gives a maximum sparking potential of 720 volts, which corresponds to a spark-gap of about a tenth of a millimetre between flat surfaces.

Energy of Radiation.—The mean energy of the radiation per unit volume is (Maxwell, Art. 793), $\frac{K E^2}{8\pi}$; which in the present case is equivalent to

$$\frac{K}{8\pi} \cdot \frac{V^2 \sin^2\theta}{4\rho^2 c^2}.$$

Taking the same oscillator as above, with $c = 4\frac{1}{2}$ and $V = 88$ electrostatic units, the mean energy of the radiation per unit volume at any considerable distance r, say 2 metres, in the equator, is

$$\frac{K V^2}{32\pi c^2 r^2} = \frac{88 \times 88}{25 \times 81\, r^2} = \frac{3{\cdot}8}{r^2} = \frac{3{\cdot}8}{4 \times 10^4} \text{ barads}$$

$= 95$ microbarads, at a distance of two metres.

This will cause a momentary pressure on a metallic surface normally exposed to it, of 95 microdynes per square centimetre, or a milligram weight per square metre; and is nearly twice as strong as full sunshine while it lasts.

At 1 metre distance, I need hardly say, the energy and the pressure are four times as great.

The area of energy absorbed by a fine wire linear receiver may be estimated roughly by finding the closeness of a grid of parallel wires which would just not let any radiation pass through it. Suppose, for instance, that a grid with wires 10 centimetres apart satisfies this condition; then each wire mops up energy for a breadth of five centimetres on either side of itself. The heat generated in such a wire at each spark is

$$\frac{3}{2} \cdot \frac{b l}{4\pi r^2} \cdot \frac{1}{2} S V_0^2.$$

This, in the numerical case already taken, with $\frac{S}{K} = 1{\cdot}4$ centimetre and $K V_0^2 = (88)^2$ dynes, gives, at a distance of 1 metre $= 32{\cdot}5$ ergs per spark; which, repeated 100 times a second by a suitable contact-breaker, would yield 3,250 ergs per second, or one ordinary thermal unit every $3\frac{1}{2}$ hours.

Appendix.—It is in accordance with theory to assert that the action of two given magnets on each other varies inversely with the permeability of the medium; that the action of two currents on each other varies directly as the permeability of the medium; and that the action of a current on a given magnet is independent of the properties of the medium.

To avoid misunderstanding, it must be perceived that the statement refers to a given magnet, not to a magnet of numerically specified strength, because about that there would be some ambiguity according to the medium in which it was measured.

Similarly, the static action between two charges is inversely as a dielectric constant of the medium; the action between a given charge moving at the approximate light-speed and a given magnet is independent of the medium; except in so far as its properties affect the velocity of light; while the dynamic action between two given charges moving together at the light-speed is proportional to the permeability.

It may be as well to have direct experimental verification for some of these things.

COMPARATIVE TESTS OF LEATHER AND CANVAS-RUBBER BELTS.*

BY SAMUEL WEBBER, C.E.

The question of belting for driving the high-speed dynamos in electric light and power stations is one of considerable importance; and one on which I am often called to express an opinion. In the first place, let me lay down as a general law, too often neglected, that the value and driving-power of a belt depends upon its complete flexibility, and also on its evenness and softness of surface, which two qualities combined permit perfect contact with, and close adhesion to, the surface of the pulleys. The next point is the weight of the belt itself, which should be as light as possible, consistent with the extreme power to be transmitted by it. This not only saves waste of power in keeping the belt itself in motion, but reduces the centrifugal action that tends to keep the belt from coming in proper contact with a small pulley at high-speed. This matter, though important, is often overstated, much of the trouble often noticed being due to the rigidity and inflexibility of the belt, particularly if a double one, rather than to its centrifugal action. If any one has ever noticed the action of one of the great cotton mill belts at Lowell or Fall River running at a speed of a mile a minute, on a pulley 5, 6, or 7ft. in diameter, he will remember that he has never seen much centrifugal action keeping the belt away from the pulley; but if he has seen a double belt even at 3,000ft. per minute run on a 12in. pulley, he will have noticed a perceptible loss of contact. For these reasons I would always discourage the use of a double belt, when a single one will answer the purpose on any reasonable width of pulley, or in any case when the pulley is less than 12in. diameter. Belts can be run as fast as 6,000ft. per minute with perfect safety, and, if flexible, will cling to the pulley and lose nothing by centrifugal action. The consideration of weight leads me to disapprove of the so-called "link belts." Even with the latest and I believe the best of these belts, the "Acme" belt of the Page Belting Company, of Concord, N.H., the weight of the belt is given me as 4lb. 4oz. per square foot, of which 3lb. 3oz. is leather, and 1lb. 1oz. iron. Now, a first-class single leather belt, $\frac{3}{16}$ in. thick, weighs just about 1lb. per square foot, and I believe that an equal weight of leather in its normal and natural condition will transmit more power, with less loss, than if chopped up into scraps and bolted together again in any way whatsoever.

The cost of leather has led to very many experiments to provide an economical substitute, and the first one of these to notice is the "rubber belt," or, in other words, a belt composed of several folds of canvas, covered and cemented together with a solution of india-rubber. For work in dye-houses and bleacheries this has proved very valuable; but it is soon destroyed by heat and dust, and I am not aware that it has been successfully used as yet for electrical purposes; in fact, with one exception, the cotton-leather belt, of which I shall speak later, I do not yet know of anything to contradict the old saw, "There's nothing like leather."

I give herewith the results of a series of experiments made by me at the factory of the Underwood Belting Company, Tolland, Conn., to test the comparative driving capacity of various entirely new belts.

The first test I will note was of an entirely new Hoyt belt, one of the best known on the market. This had been in stock some time, but was tested as it was for the sake of information. This belt was 12in. wide, $\frac{1}{4}$in. thick, 31ft. long, and weighed $34\frac{1}{2}$lb. With a tension of $43\frac{1}{2}$lb. it drove seven horse-power (at 754ft. per minute) and then slipped off from stiffness and lack of sufficient tension. The strain was then increased to $62\frac{1}{2}$lb. per foot, and the

* From the *Electrical World* of New York.

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belt shortened, in doing so, 4½in. It now carried 7·77 horse-power at 697ft. per minute, and with a load of 11·64 horse-power slipped 10½ per cent., and slipped off when the load was increased. The strain was then increased to 83⅓lb. per inch, which shortened it 2½in. more, and it now carried 8 88 horse-power at 697ft. per minute without slip. As more load was added it began to slip, increasing until with a load of 14·77 horse-power at 660ft. per minute it slipped 13 per cent. and with increased load slipped off. The belt was then reversed, bringing the softer flesh side to the pulley, the hair side having been previously used. It now carried 16·85 horse-power at 662ft. per minute, and then "jumped the pulley" suddenly with increased load, without having shown any perceptible slip previously. This test showed that on the polished iron pulley, the soft-flesh side *held* better than the harder *grain*. A pair of Dodge's wooden pulleys were now put on and the belt replaced, with the hair side to the pulley. We now got 15·29 horse-power without slip, at 739ft. per minute, but additional load caused a slip which increased with the load, so that little more power was shown, and the test was stopped at 15·80 horse-power, with the belt still on the pulleys, showing a horse-power for each inch of width, at 562ft. per minute. The next test was to cut the belt down to 8½in. wide, which gave an apparent strain of 117·6lb. per inch, as it was simply relaced in the old holes. This on the wooden pulleys gave 10·19 horse-power without slip at 711ft. per minute, and 11·79 horse-power with a slip of 3·77 per cent. at 699lb., and then went off with increased load. A pair of paper pulleys from Westinghouse, Church, Kerr, and Co., were then substituted, and the belt replaced as in the last trial. It now gave on these pulleys 15·69 horse-power without slip at 704ft. per minute, or at the rate of 1 horse-power per inch, for 374ft. velocity. This finished the trials of this belt, which came out as good as new, and had not stretched an inch when we got through with it.

We will now compare this with a series of tests of a very soft and flexible belt, known as the "Schultz Rawhide Belt," under the same conditions. This belt, 31ft. long, 12in. wide, and 3-16in. thick, weighed 29lb. It was first tried, as before, with a strain of 43lb. per inch on iron pulleys, grain side to the pulley. This likewise proved to be an insufficient strain, and after giving 6 horse-power without slip, and 9·48 horse-power with a slip of 8·43 per cent. ; at 725ft. per minute, it went off the pulley with increased load. With the increase of strain to 62½lb. per inch it gave 11·10 horse-power at 697ft. per minute, and 16·27 horse-power with 5 66 per cent. slip at 675ft. per minute, slipping off with increased load. With a strain of 83⅓lb. per inch we got 15·79 without slip at 667ft. per minute, and 19 horse-power with 5·66 per cent. slip at same speed, going off with increased load. This showed 421ft. per minute per horse-power per inch. We then put on the wooden pulleys, relacing the belt in the old holes, and got 19·80 horse-power without slip at 691ft. per minute, and 26·16 horse-power with a slip of 3 per cent. at 705ft. per minute. With an additional load we got 26·87 at 693ft. per minute with a slip of 4·59 per cent., and with more load "stalled the engine." This last test showed 309ft. per minute per horse-power for each inch of width, and fairly illustrates the difference between a stiff and a flexible belt. We, however, split this belt down as we had the other one to 8½ins. wide and repeated on the wooden pulleys. Lacing in the old holes, we now got the strain of 117·6lbs. per inch, which proved too much for the belt, for although we now got 22 horse-power, at 691ft. per minute, *without slip*, or at a speed of 261ft. per minute for each inch of width, the belt "jumped the pulleys" with the next increase of load, and when we tried it on the paper pulleys we only got 16·46 horse-power without slip, at 739ft. per minute. The belt slipped off with the next increased load, and on applying the scales we found that the tension had fallen to 77·7lbs. per inch, and on taking it off we found it permanently stretched 1⅞ins. We were perfectly aware all the time that we were overloading the belt, but our object was to find how much it would stand.

These experiments confirm the already well established fact that a leather belt will safely bear a strain of 350lb. per square inch of area, or 87½lb. per inch of width for a belt one-fourth inch thick, or 66lb. for one of $\frac{3}{16}$in., or an ordinary single belt, and that the latter in good condition, soft and flexible, will easily convey one horse-power for each inch of width at 600ft. per minute. They also show very plainly the difference in the hold on the pulley of rigid and flexible belts, and this difference would increase with the velocity on small pulleys, as both the centrifugal force and the entrainment of air would be greater. An ingenious perforated belt for high speed has been introduced lately by Messrs. Charles A. Schieren and Co., of New York, which I have not seen in operation, but of which the samples impress me favourably. The slight longitudinal perforations are not sufficient to materially weaken the belt, while at the same time they afford an easy passage for entrained air.

I may be thought severe on "link-belts," but my opposition to them is based on sound mechanical principles for high speed, and if a great power at low speed is required. When shafts and gears are impracticable I should use a metallic link or chain on "sprocket pulleys," rather than trust to friction. With these remarks I will leave the subject of "leather," and turn to my notes on canvas belts of different kinds.

The series of experiments to which I have referred shows a test of a simple canvas or duck belt without any preparation. This belt, 31ft. long, 12in. wide, $\frac{3}{16}$in. thick, weighed 21½lb. It stretched 13¼in., with a strain of 43⅓lb. per inch, gave 4·86 horse-power without slip at 754ft. per minute, slipped 3·83 per cent. with 5 horse-power, and slipped off with increased load. When saturated with size, under a strain of 83⅓lb. per inch, it carried 5·75 horse-power without slip, at 739ft. per minute, then began to slip as the load was increased, until it went off after giving 10·35 horse-power with 9 per cent. slip.

Next came a "Main" or "Gandy Belt," 31ft. long, 12in. wide, and 38-16 thick, weighing 41½lb. It was composed of heavy cotton cloth, folded and stitched, and saturated with oil and red paint. It stretched 13¼in. before lacing with a strain of 43⅓lb. per inch. It carried 7·20 horse-power without slip at 754ft. per minute ; with 8·43 horse-power it slipped 8½ per cent., and went off with increased load. With a strain of 62½lb. per inch it stretched 2in. more, and drove 8·08 horse-power without slip at 725ft. per minute, slipped 8·70 per cent. with 9·48 horse-power, and then slipped off. With 83⅓lb. per inch it stretched 3in. more, and carried 10·48 horse-power without slip at 732ft. per minute. With 14·22 horse-power it slipped 10 per cent., and then went off.

Next came a four-ply duck belt, weighing just one pound per foot, and saturated with linseed oil and plumbago. This stretched 7¾in. with 43⅓lb. per inch, and drove only 2·40 horse-power without slip, it having been dusted with powdered soapstone, to keep it from sticking together in the fold. The soapstone got rid of, and the strain increased to 62½lb. per inch, it carried 13·27 horse-power without slip, and went off with an increase of load. At 83⅓lb. per inch, it carried 16 65 horse-power without slip at 697ft. per minute, but slipped 5·71 per cent. with 17·28 horse power, and then off.

A first-class rubber belt of same dimensions, weighing 37lb., showed *no slip* in any test until it finally *jumped* the pulleys, giving 8·07 horse-power at 725ft. per minute, with 43⅓lb. strain ; 13·68 horse-power at 660ft. per minute, with 62½lb. strain, and 18·61 horse-power at 650ft. per minute, with 83⅓lb. strain, the last test starting the rubber covering. The variations in speed were due to the incapacity of the engine to carry these loads in addition to its regular work.

We now come to the cotton duck leather-lined belt already mentioned. This belt was a four-ply duck, with a soft leather lining cemented on, and weighed 37½lb. of the same size as the others, but was ¼in. thick, or $\frac{3}{16}$in. duck and $\frac{1}{16}$th leather. It stretched 2¼in. with 43⅓lb., and drove 10·80 horse-power without slip at 754ft. With 12·4 horse-power, it slipped 13 per cent., and then slipped off. With 62½lb. per inch strain, it carried 11·88 horse-power without slip at 747ft. per minute, stretching 2¼in. It carried 19·40 horse-power, with 14·7 per cent. slip at 711ft., and then slowed down the engine without going off. With the steam increased to 83⅓lb., it carried 16·98 horse-power without slip at 711ft. per minute, and with 21 horse-power and 9 per cent. slip slowed down the engine to 690ft., and the test was stopped with the belt still on. All these last tests were on iron pulleys. We now changed to the wooden ones, and got 27·87 horse-power without slip, stopping the engine. We then split the belt down to 8½in., or 117lb. per inch, and on the same pulleys got 25½ horse-power, with 1 per cent. slip. Changing to paper pulleys, we got 25·30 horse-power *without* slip, but exhausted our power as before ; and on applying the scales, found the belt to still hold its strain of 1,000lb. As will be seen from the above tests, we could not get higher speed with these belts, so we took a five-ply belt of same kind, 5in. wide, $\frac{5}{16}$in. thick, 31ft. 2in. long, weighing 19lb. This stretched 2¼in. under a strain of 77lb. per inch, and gave 7·20 horse-power on iron pulleys without slip at 754ft. per minute. With 9·80 horse-power it slipped 3½ft., and with increased load slipped off. On wooden pulleys it drove 10·19 horse-power without slip at 711ft. per minute, or at the rate of 348ft. of belt per minute for a horse-power to each inch. We then put back the iron pulleys and increased the strain to 117 pounds per inch, and got 10·29 horse-power without slip at 718ft., and 12·63 horse-power at 698ft., with 5·65 per cent. slip. We then put on a larger pulley to increase the speed, and under the same strain got 18·62 horse-power without slip at 1,301ft. per minute, and 24 horse-power with 1·50 per cent. slip at 1,276ft., 24·59 horse-power with 3·10 per cent. slip, and 24 horse-power with 5 50 per cent. slip at 1,222ft. per minute, slowing down the engine, so that we could not continue the tests. These last two tests, however, go to prove that the slip does not increase with the velocity, and the last three were all stopped in good order, with the belts still on the pulleys. I think they go to prove that a strong light-woven belt, with a leather lining, if the cement is perfect, will be the belt of the future for all magneto-electro machines, as they combine great strength with light weight and great clinging properties.

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I do not propose to enter into any discussion which may involve patent rights, but will simply say that while these cotton-leather belts tested were made by the Underwood Manufacturing Company, a very promising belt of the same materials is also made by the Page Belting Company, of Concord, N.H., differing in construction thus:—Two canvass belts are used, meeting in the centre, with a single leather lining, which acts as a hinge, and permits the belt to adapt itself closely to a *coned* pulley.

THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON.

(Continued from page 686.)

We are now in a position to understand the bearing of some curious and important researches made about forty years ago by Dr. Julius Dub, which, like a great many other good things, lie buried in the back volumes of Poggendorff's *Annalen*. Some account of them is also given in Dr. Dub's now obsolete book, entitled "Elektromagnetismus."

The first of Dub's experiments to which I will refer relates to the difference in behaviour between electro-magnets with flat and those with pointed pole ends. He formed two cylindrical cores each six inches long, from the same rod of soft iron, one inch in diameter. Either of these could be slipped into an appropriate magnetising coil. One of them had the end left flat, the other had its end pointed, or rather, it was coned down until the flat end was left only ½in. in diameter, possessing therefore only one-fourth of the

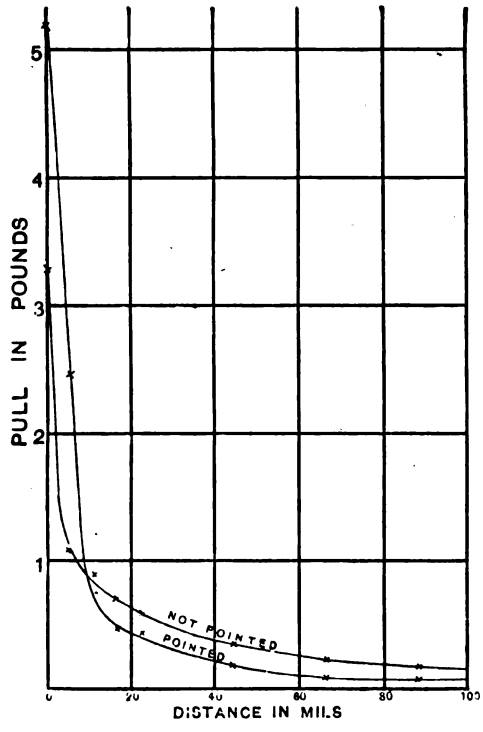

FIG. 35.—Contrasted Effect of Flat and Pointed Poles.

amount of contact surface which the other core possessed. As an armature there was used another piece of the same soft iron rod, 12in. long. The pull of the electro-magnet on the armature at different distances was carefully measured, with the following results:—

Distance apart in inches.	Pull on flat pole (lb.).	Pull on pointed pole (lb.).
0	3·3	5·2
0·0055	1·1	1 8
0·0110	0 9	0·75
0·0165	0·71	0·50
0 022	0 60	0·42
0·044	0·38	0·20
0·088	0·19	0·09

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

These results are plotted out in the curves in Fig. 35. It will be seen that in contact, and at very short distances, the reduced pole gave the greater pull. At about ten mils distance there was equality, but at all distances greater than ten mils the flat pole had the advantage. At small distances the concentration of magnetic lines gave, in accordance with the law of traction, the advantage to the reduced pole. But this advantage was, at the greater distances, more than outweighed by the fact that with the greater widths of air-gap the use of the pole with larger face reduced the magnetic reluctance of the gap and promoted a larger flow of magnetic lines into the end of the armature.

Dub's next experiment relate to the employment of polar extensions or pole-pieces attached to the core. These experiments are so curious, so unexpected unless you know the reasons why, that I invite your especial attention to them. If an engineer had to make a firm joint between two pieces of metal, and he feared that a mere attachment of one to the other was not adequately strong, his first and most natural impulse is to enlarge the parts that come together—to give one as it were a broader footing against the other. And that is precisely what an engineer, if uninstructed in the true principles of magnetism, would do in order to make an electro-magnet stick more tightly on to its armature. He would enlarge the ends of one or both. He would add pole pieces to give the armature a better foothold. Nothing, as you will see, could be more disastrous, Dub employed in these experiments a straight electro-magnet having a cylindrical soft-iron core 1in. in diameter, 12in. long; and as armature a piece of the same iron, 6in. long. Both were flat-ended. Then six pieces of soft iron were prepared of various sizes to serve as pole pieces. They could be screwed on at will either to to the end of the magnet core or to that of the armature. To distinguish them we will call them by the letters A, B, C, &c. Their dimensions were as follows, the inches being presumably Bavarian inches:—

Piece.	Diameter.	Length.
	inches.	inches.
A	2	1
B	1⅝	1¼
C	1⅜	2
D	2	½
E	1½	1
F	1	2

Of the results obtained with these pieces we will select eight. They are those illustrated by the eight collected sketches in Fig. 36. The pull required to detach was measured, also the attraction exerted at a certain distance apart.

Experiment.	On magnet.	On armature.	Traction.	Attraction.
I.	none	none	48	22
II.	D	none	30	10
III.	E	none	32	11·5
IV.	C	none	35	13·5
V.	D	A	20	7·5
VI.	none	B	50	25
VII.	none	D	43	25
VIII.	none	C	50	18

It will be noted that, in every case, putting on a pole-piece to the end of the magnet diminished both the pull in contact and the attraction at a distance; it simply promoted leakage and dissipation of the magnetic lines. The worst case of all was that in which there were pole pieces both on the magnet and on the armature. In the last three cases the pull was increased, but here the enlarged piece was attached to the armature, so that it helped those magnetic lines which came up into it to flow back laterally to the bottom end of the electro-magnet, while thus reducing the magnetic reluctance of the return path through the air, and so increasing the total number of magnetic lines, did not spread unduly those that issued up from the end of the core.

The next of Dub's results relate to the effect of adding these pole-pieces to an electro-magnet 12 inches long, which was being employed, broadside on, to deflect a distant compass needle. (Fig. 37.)

Pole-piece used.	Deflection (degrees).
None	34·5
A	42
B	41·5
C	40·5
D	41
E	39
F	38

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In another set of experiments of the same order a permanent magnet of steel, having poles *n s*, was slung horizontally by a bifilar suspension, to give it a strong tendency to set in a particular direction. At a short distance laterally was fixed the same bar electro-magnet, and the same pole-pieces were again employed. The results of attaching the pole-pieces at the rear end are not very conclusive; they slightly increased the deflection. But in the absence of information as to the distance between the steel magnet and the electro-magnet, it is difficult to assign proper values to all the causes at work. The results were :—

Pole-piece used.	Deflection (degrees).
None	8·5
A	9·2
B	9·5
C	10
D	8·8

When, however, the pole-pieces were attached to the distant end of the electro-magnet, where their effect would undoubtedly be to promote the leakage of magnetic lines into the air at the front end without much affecting the distribution of these lines in the space in front of the pole, the action was more marked.

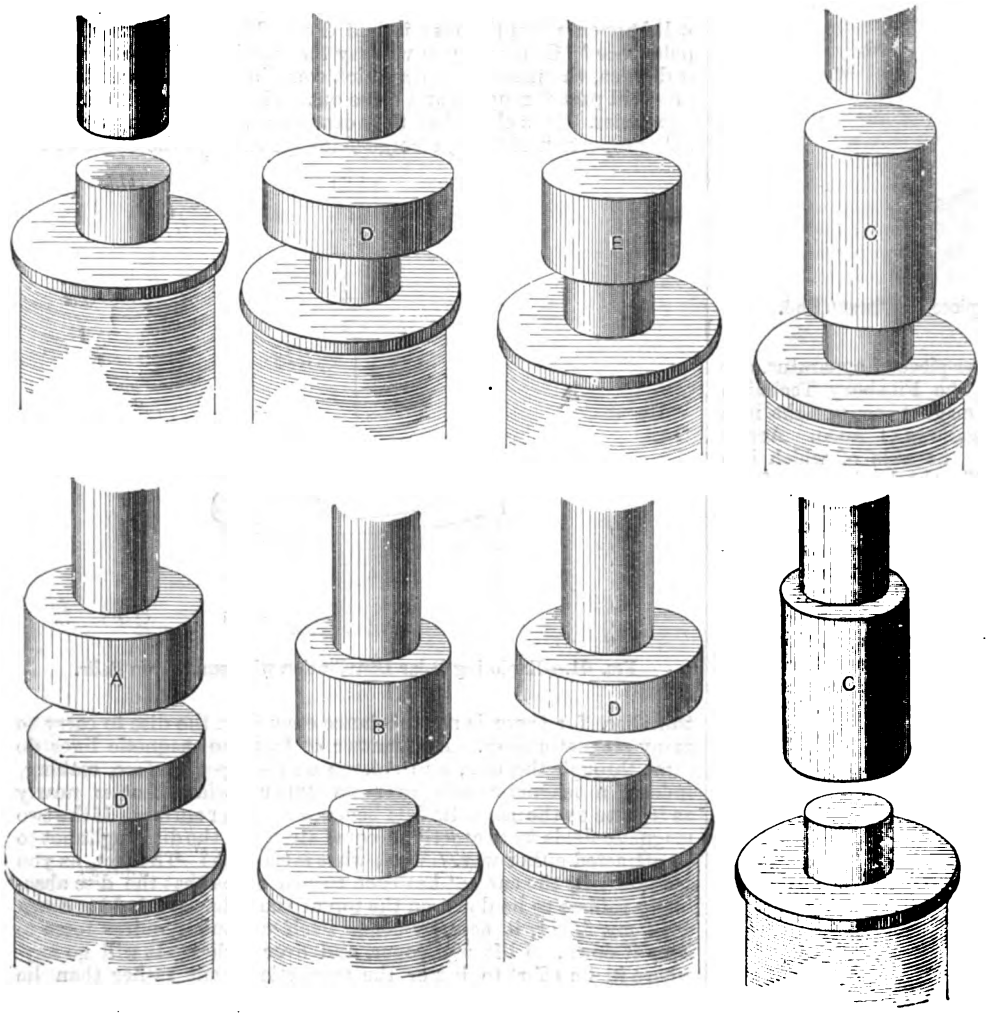

Fig. 36.—Dub's Experiments with Pole-pieces.

Pole-piece used.	Deflection (degrees).
None	8·5
A	10·0
B	10·3
C	10·3
F	10·1

Still confining ourselves to straight electro-magnets, I now invite your attention to some experiments made in 1862 by the late Count Du Moncel as to the effect of adding a polar expansion to the iron core. He used as his core a small iron tube, the end of which he could close up with an iron plug, and around which he placed an iron ring which fitted closely on to the pole. He used a special lever arrangement to measure the attraction exercised upon an armature distant in all cases one millimetre from the pole. The results were as follows : –

—	Without ring on pole.	With ring on pole.
Tubular core alone	11	10
Ditto, with iron plug	17	14
Core provided with mass of iron at distant end	27	25
Ditto, ditto, with iron plug	38	33

After hunting up these researches, it was extremely interesting to find that so important a fact had not escaped the observant eye of the original inventor of the electro-magnet. In Sturgeon's "Experimental Researches" (p. 113) there is a footnote, written apparently about the year 1832, which runs as follows :—

An electro-magnet of the above description, weighing three ounces, and furnished with one coil of wire, supported 14lb. The poles were afterwards made to expose a larger surface by welding to each end of the cylindric bar a square piece of good soft iron; with this alteration only the lifting power was reduced to about 5lb., although the magnet was annealed as much as possible.

We saw that this straight electro-magnet, whether used broad-side-on or end-on, could act on the compass needle at some distance from it, and deflect it. In those experiments there was no return-path for the magnetic lines that flowed through the iron core save that afforded by the surrounding air. The lines flowed round in wide-sweeping curves from one end to the other, as in Fig. 26, the magnetic field being quite extensive. Now, what will happen if we provide a return path? Suppose I surround the electro-magnet with an iron tube of the same length as itself, the lines will flow along in one direction through the core, and will find an easy path back along the outside of the coil. Will the magnet thus jacketed pull more powerfully or less on that little suspended magnet? I should expect it to pull less powerfully; for if the magnetic lines have a good return path here through the iron tube, why should they force themselves in such a quantity to a distance through air in order to get home? No, they will naturally return short back from the end of the core into the tubular iron

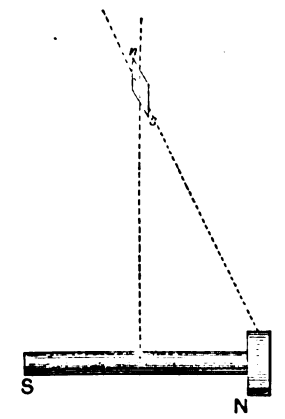

Fig. 37.—Dub's Deflection Experiment.

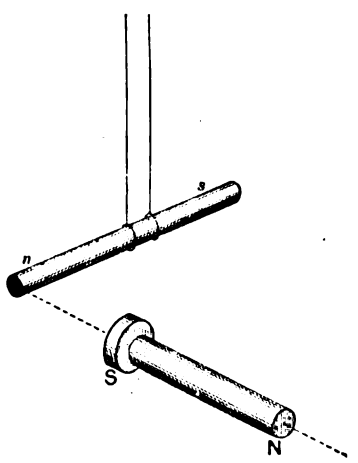

Fig. 38.—Deflecting a Steel Magnet having Bifilar Suspension, Pole-piece on Near End

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jacket. That is to say, the action at a distance ought to be diminished by putting on that iron tube outside. Here is the experiment set up. And you see that when I turn on the current my indicating needle is scarcely affected at all. The iron jacket causes that magnet to have much *less* action at a distance. Yet I have known people who actually proposed to use jacketed magnets of this sort in telegraph instruments and in electric motors, on the ground that they give a bigger pull. You have seen that they produce less action at a distance across the air, but there yet remains the question whether they give a bigger pull in contact? Yes, undoubtedly they do; because everything that is helping the magnetism to get round to the other end increases the goodness of the magnetic circuit, and therefore increases the total magnetic flux.

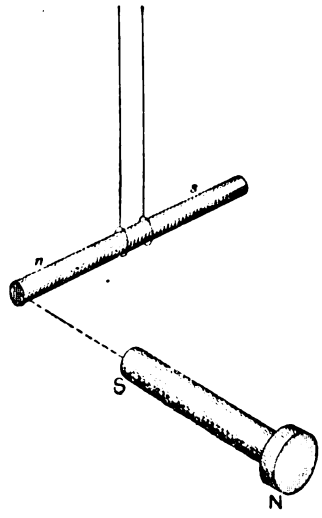

FIG. 39.—Deflecting Steel Magnet, Pole-piece on Distant End.

We will try this experiment upon another piece of apparatus, one which has been used for some years at the Finsbury Technical College. It consists of a straight electro-magnet, set upright in a base-board, over which is erected a light gallows of wood. Across the frame of the gallows goes a winch, on the axle of which is a small pulley with a cord knotted to it. To the lower end of the cord is hung a common spring balance, from the hook of which depends a small horizontal disc of iron to act as an armature. By means of the winch I lower this disc down to the top of the electro-magnet. The current is turned on; the disc is attracted. On winding up the winch I increase the upward pull until the disc is detached. See, it required about 9lb. to pull it off. I now slip over the electro-magnet, without in any way attaching it, this loose jacket of iron—a tube, the upper end of which stands flush with the upper polar surface. Once more I lower the disc, and this time it attaches itself at its middle to the central pole, and at its edges

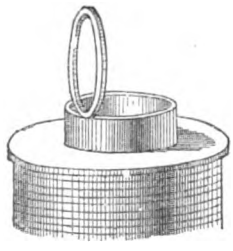

FIG. 40.—Experiment with Tubular Core and Iron Ring.

to the tube. What force will now be required to detach it? The tube weighs about ½lb., and it is not fixed at the bottom. Will 9½lb. suffice to lift the disc? By no means. My balance only measures up to 24lb., and even that pull will not suffice to detach the disc. I know of one case where the pull of the straight core was increased 16-fold by the mere addition of a good return-path of iron to complete the magnetic circuit. It is curious how often the use of a tubular jacket to an electro-magnet has been re-invented. It dates back to about 1850, and has been variously claimed for Romershausen, for Guillemin, and for Fabre. It is described in Davis's "Magnetism," published in Boston in 1855. About 16 years ago Mr. Faulkner, of Manchester, revived it, under the name of the *Altandae* electro-magnet. A discussion upon jacketed electro-magnets took place in 1876, at the Society of Telegraph Engineers; and in the same year, Prof. Graham Bell used the same form of electro-magnet in the receiver of the telephone which he exhibited at the Centennial Exhibition. But the jacketed form is not good for anything except increasing the tractive power. Jacketing an electro-magnet which already possesses a return circuit of iron is an absurdity. For this reason the proposal made by one inventor to put iron tubes outside the coils of a horse-shoe electro-magnet is one to be avoided.

We will take another paradox, which equally can be explained by the principle of the magnetic circuit. Suppose you take an iron tube as an interior core; suppose you cut a little piece off the end of it; a mere ring of the same size. Take that little piece and lay it down on the end. It will be struck with a certain amount of pull. It will pull off easily. Take that same round piece of iron, put it on edge-wise, where it only touches one point of the circumference, and it will stick on a good deal tighter, because it is there in a position to increase the magnetic flow of the magnetic lines. By concentrating the flow of magnetic lines over a small surface of contact increases B at that point, and B^2, integraded over the lesser area of the contact, gives a total bigger pull than is the case when the edge is touched all round against the edge of the tube.

Here is a still more curious experiment. I use a cylindrical electro-magnet set up on end, the core of which has at the top a flat circular polar surface about two inches in diameter. I now take a round disc of thin iron—ferrotype or tin-plate will answer quite well—which is a little smaller than the polar face. What will happen when this disc is laid down flat and centrally on the polar face? Of course you will say that it will stick tightly on. If it does so, the magnetic lines which come in through its under surface will pass through it and come out on its upper surface in large quantities. It is clear that they cannot all, or even any considerable proportion of them, emerge sideways through the edges of the

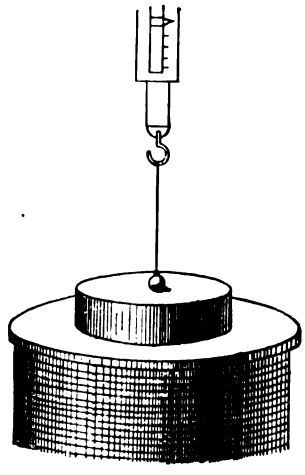

FIG. 41.—Exploring Polar Distribution with small Iron Balls.

thin disc, for there is not substance enough in the disc to carry so many magnetic lines. As a matter of fact the magnetic lines do come through the disc, and emerge on its upper surface, making, indeed, a magnetic field over its upper surface that is nearly as intense as the magnetic field beneath its under surface. If the two magnetic fields were exactly of equal strength, the disc ought not to be attracted either way. Well, what is the fact? The fact, as you see now that the current has been turned on, is that the disc absolutely refuses to lie down on the top of the pole. If I hold it down with my finger, it actually bends itself up, and requires force to keep it down. I lift my finger, and over it flies. It will go anywhere in its effort to better the magnetic circuit rather than lie flat on the top of the pole.

Next I invite your attention to some experiments, originally due to Von Kolke, published in the "Annalen" forty years ago, respecting the distribution of the magnetic lines where they emerge from the polar surface of an electro-magnet. I cannot enumerate them all, but will merely illustrate them by a single example. Here is a straight electro-magnet, with a cylindrical, flat-ended core (Fig. 41). In what way will the magnetic lines be distributed over at the end? Fig. 41 illustrates roughly the way in which, when there is no return-path of iron, the magnetic lines leak through the air. The main leakage is through the ends, though there is some at the sides also. Now the question of the end-distribution we shall try by using a small bullet of iron, which will be placed at different points from the middle to the edge, a spring balance being employed to measure the force required to detach it. The pull at the edge is much stronger than at the middle, at least four or five times as great. There is a regular increase of pull from the middle to the edge. The magnetic lines, in trying to complete their own circuit, flow most numerously in that direction where they can go furthest through iron on their journey. They leak out

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more strongly at all edges and corners of a polar surface. They do not flow out so strongly at the middle of the end surface, otherwise they would have to go through a larger air-circuit to get back home. The iron is consequently more saturated round the edge than at the middle; therefore, with a very small magnetising force, there is a great disproportion between pull at the middle and that at the edges. With a very large magnetising force you do not get the same disproportion, because if the edge is already far saturated you cannot by applying higher magnetising power increase its magnetisation much, but you can still force more lines through the middle. The consequence is, if you plot out the results of a succession of experiments of the pull at different points, the curves obtained are, with larger magnetising forces, more nearly straight than are those obtained with small magnetising forces. I have known cases where the pull at the edge was six or seven times as great as in the middle with a small magnetising power; but with larger power not more than two or three times as great, although, of course, the pull all over was greater. You can easily observe this distribution by merely putting a polished iron ball upon the end of the elecro-magnet, as in Fig. 42. The ball at once rolls to the edge, and will not stay at the middle. If I take a larger two-pole electro-magnet (like Fig. 11) what will the case now be? Clearly the shortest path of the magnetic lines through the air is the path just across from the edge of one polar surface to the edge of the other between the poles. The lines are most dense in the region where they arch over in as short an arch as possible, and they will be less dense along the longer paths, which arch more widely over. Therefore, as there is a greater tendency to leak from the inner edge of one pole to the inner edge of the other, and less tendency to leak from the outer edge of one to the outer edge of the other, the biggest pull ought to be on the inner edges of the pole. We will now try it. On putting the iron ball anywhere on the pole it immediately rolls until it stands perpendicularly over the inner edge.

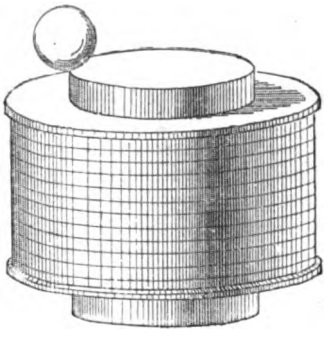

Fig. 42.—Iron Ball attracted to edge of Polar Face.

The magnetic behaviour of little iron balls is very curious. A small round piece of iron does not tend to move at all in the most powerful magnetic field if that magnetic field is uniform. All that a small ball of iron tends to do is to move from a place where the magnetic field is weak to a place where the magnetic field is strong. Upon that fact depends the construction of several important instruments, and also certain pieces of electro-magnetic mechanism.

(To be continued.)

SECONDARY CELLS.*

BY W. J. S. BARBOUR STARKEY.

The author in this Paper limited himself to a description of his own experiences in regard to secondary cells, primarily with a view to provoke discussion on the subject. Soon after the introduction of M. Faure's cells his attention was drawn to the hard film of sulphate of lead formed on the plates, which materially interfered with their efficiency; and, as a result of experiments, he ascertained that the addition of a small quantity of carbonate of soda to the dilute acid served to remedy this evil, even when the cells were allowed to remain idle for a considerable time. Subsequently, in the case of a small installation of 22 E.P.S., 350 ampere-hour cells, the plates of which showed signs of sulphating, carbonate of soda ordinary washing soda), was added in small quantities, and on proceeding with the charging the plates were restored to their original condition. The cells thus treated have since been in use for a period of five years, and are now in perfect condition. The subsequent experiments on this subject by Mr. Preece were then alluded to. The author advised that large cells be used for stationary work, and that they be both charged and discharged at low rates. Various details in regard to the management of cells were discussed, the practice of packing the plates in a solid though porous mass formed by mixing plaster of Paris and sawdust being specially recommended. The Paper concluded with the expression of a hope that a thoroughly practical cell for traction purposes might be introduced —one which will stand rough usage and be free from the defects which characterise those at present in use.

* Abstract of a Paper read before the British Association in Section G Leeds, September, 1890.

ON A MERCURY ELEMENT IN RELATION TO TEMPERATURE.*

BY F. STEINITZ.

The combination $Ag/AgSO_4/Hg_2SO_4/Hg$, which exhibits a marked change under different temperatures, seemed to the author peculiarly adapted for the study of Helmholtz's theory, that the difference between the electrical and the chemical energy of an element is equivalent to the product of the absolute temperature and the differential coefficient of the difference of potential between the poles. If the chemical energy overcomes the electrical energy, in which case a current is generated, the coefficient is negative; if the reverse is the case, it is positive. The elements used consisted of two glass vessels, 6·5 cm. high and 2·5 cm. wide, connected by a capillary tube. In both vessels was placed mercury, into which in the second vessel was plunged a platinum wire. On the mercury in the first vessel was placed a layer of paste of mercurous sulphate and silver sulphate, and on this the silver sulphate solution was carefully poured. In the silver sulphate solution a silver wire spiral and a thermometer were immersed. The whole was put into a copper vessel containing water.

The changes in the E.M.F. varied considerably with the time. The first reading was ·0295 volt at 13·8°C. The tests at various temperatures give rise to the assumption that the E.M.F. is a linear function of the temperature. The results show that the agreement between the theory and the experiments is complete in cases of actions of a reversible nature. It would also seem that even with actions not belonging to this class the theory would lead to correct conclusions.

* From the *Wiener Berichter.*

ON THE CONDUCTIVITY OF SOLID AND FUSED SALTS.†

BY L. GRATZ.

The data hitherto published on the conductivity of solid and fused salts differ for each salt when determined by different observers. The author was extremely careful to keep the salts at constant and accurately measured temperatures. The salts were fused in a small porcelain crucible 2·8 cm. high and 2·2 cm. diam., heated equally in a sand bath. In the salt were placed stout, square, platinum electrodes of 2·25 square cm. surface. The electrodes were freshly platinised before each test. To prevent cooling of the electrodes by conduction of heat through the connecting wires, about 20 cm. of the latter were also put in the same bath. The resistance of the salt was measured by the alternate current and an electro dynamometer. The capacity of the crucible was determined by a solution of magnesium sulphate. All readings were taken with decreasing temperatures.

In spite of the fact that many of the salts on solidifying showed porosity, a general agreement was found between the results for the same salt in the solid and fused state. With some salts, just at the point of fusion, a remarkable change occurs in the volume or in their conductivity; with others, the conductivity alters rapidly at a temperature below the fusing point; and with a third group, a steady change only is observed. It appears, therefore, that the only difference between salts in the solid and fused state is due to an action of an electrolytic nature, as Warburg has already proved in the case of glass and crystal. Clausius' theory, therefore, that in solid bodies the molecules oscillate about a position of equilibrium, but cannot separate from their own group, cannot be accepted. The idea of a sharply-defined difference between solids and liquids must also be abandoned, as it seems to have no existence in Nature. Liquid molecules exist in every solid, even when the latter show no approach to the softened state.

† From Wiedemann's *Annalen*, Vol. 40, No. 5.

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REVIEWS.

Elementary Manual of Electricity and Magnetism. By ANDREW JAMIESON, M.Inst.C.E. (Griffin and Co., London, 1890.)

It appears to be inevitable that as many elementary text books must be written as there are technical colleges. If all these were of the highest quality the "unattached" student would have a wide choice, though the members of the respective institutions must needs pay attention to those of their teachers if they desire to distinguish themselves in the examinations. The book before us, though in some respects open to criticism, may certainly be classed among the best. But it is difficult to estimate its value, since it is merely an introduction to a more advanced textbook which is in preparation. It consists of three parts, each divided into lectures. It is a pity that a list of contents is given separately at the commencement of each section, and that there is no index whatever.

Reduction Tables for Readings by the Gauss-Poggendorff Mirror Method. By Dr. PAUL CZERMAK. (Berlin: 1890.)

The Gauss-Poggendorff mirror method is the correct but little-used name for the arrangement of mirror, scale, and telescope, which are employed in all laboratories for the measurement of the deflections of various instruments. The tables are for facilitating the reduction of readings to tan ϕ, sin $\phi/2$ and ϕ in degrees, where ϕ is the angle through which the mirror moves. The tables give the distance of the mirror from the scale at every 10cm. from 1m. metre to 2m., and at every 20cm. from 2m. to 4m. The scale readings are given at every 10mm. up to 500mm. Linear interpolation may be used between these without appreciable error.

The tables are preceded by a description of the adjustments and corrections. The limits of accuracy for various scale distances are discussed, and it is suggested that the scale itself should be used in determining the scale distance, &c. The corrections are of a rather hair-splitting order, but it is useful to have them on record, clearly discussed with approximate formulæ for their elimination. For the displacement of the ray due to a parallel piece of glass in front of the mirror, one-third of its thickness should be subtracted from the scale-distance, and for similar reasons it is shown that those who may care to do so should add the thickness of the mirror to the scale distance. Corrections for curved glass in front of the mirror, for inclination of the mirror from the vertical, for its eccentricity and curvature are given. The whole of the work is written in parallel columns in German, English, and French.

Tables to find the Working Speed of Cables. Comprising also data as to diameter capacity and copper resistance of all cores. By ARTHUR DEARLOVE. (Spon and Co., London, 1890.)

This little pocket book of 20 pages has been computed from results recently obtained in the commercial working of cables. The first table gives the number of words per minute for cables of from 100lb. to 500lb. of copper, various weights of G.P., various diameters of cores, and gives also the ratio of copper to G.P., the C.R. per unit at 45°F. and at 75°F., the capacity per unit, and the C.R. × capacity × length^2. Five letters are reckoned to a word for ordinary work, and it is pointed out that experience has shown that where a code is used the words will average about eight letters. The second table gives reduction to knots up to 4,000, enabling the speed for a cable of any length to be easily computed.

BOOKS, &c., RECEIVED.

"Report on a Series of Red-hot Furnace Crown Experiments." (Manchester: Chas. Sever.)

"Proceedings of the Royal Society." Vol. XLVIII., No. 294. (London: Harrison and Sons.)

"Proceedings of the Royal Society of Edinburgh." Vol. XVII. (pp. 129-256).

"Traité d'Électricité et de Magnétisme." By A. Vaschy. Vols. I. and II. (Paris: Baudrie et Cie.)

"Water Purification for Manufacturers and Steam Users.' (London: The London Printing Company, Plough-court, E.C.)

"Der Betrieb und die Schaltungen der Elektrischen Telegraphen." By Dr. Karl Eduard Zetsche. Vol. II. (Halle: Wilhelm Knapp.)

"Sound, Light, and Heat." By J. Spencer, B.Sc. (London: Percival & Co.)

"Fortschritte der Elektrotechnik." Edited by Dr. Karl Strecker. Vol. II., 1889. (Berlin: Julius Springer.)

"Manuel Pratique de l'Installation de la Lumière Électrique." By J. P. Anney. (Paris: B. Tignol.)

"Technology Quarterly." Vol. III., No. 3. (Boston: Massachusetts Institute of Technology.)

"The Journal of the Franklin Institute." Vol. CXXX., No. 778. (Philadelphia: Franklin Institute.)

"Reduction Tables for Readings by the Gauss-Poggendorff Mirror Method." In English, French, and German. By Von Dr. Paul Czermak. (Berlin, 1890.)

"Elementary Manual of Magnetism and Electricity." By Andrew Jamieson, M.Inst.C.E. (London: Charles Griffin and Co.)

"Tables to Find the Working Speed of Cables." Comprising also data as to diameter, capacity, and copper resistance of all cores. By Arthur Dearlove. (London: E. and F. N. Spon. 1890.)

"Practical Inorganic Chemistry. (Elementary Stage)." By E. J. Cox. (London: Percival and Co.)

"Magnetism and Electricity. (Elementary Stage)." By J. Spencer, B.Sc. (London: Percival and Co.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October* 10, 1890.

Meeting of the National Street Railway Association.—The electrical event of the coming week is the meeting of the National Street Railway Association in Buffalo. A large number of electrical people will attend, as much of the interest of the meeting centres about the developments of electric street railroads. Several of the Papers read will deal with various aspects of the subject, and it is highly probable that some very interesting facts will be elicited. Two years ago the electric motor hardly had a place in the deliberations of this body, but to-day the horse is pretty completely in the background and receives only passing attention.

The Westinghouse Traction Motor.—Some few details of the Westinghouse street railway motor have now been made public. It differs in general appearance very little from the forms already familiar, but the mechanical construction is somewhat peculiar. A single casting supports the car axle and gearing, and the armature spindle, which is in the form of a square frame, and the motor proper is carried within it, the pole-pieces being hinged at the back and clasped together about the armature by being screwed to a brass block which secures them to each other and to the front of the casting. By removing the retaining poles the pole-pieces can be swung back and the field coils pulled all over them if there is need of removing them for any cause. The same process allows a most easy removal of the armature. It is a heavy solidly-built machine, with many good mechanical features.

The "Portelectric."—The New England Portelectric Company has been trying some fairly successful experiments recently. The portelectric, it will be remembered, is a motor device in which a long iron car is acted upon directly by the attraction of solenoids distributed along the track. In the Portelectric system these solenoids are about 6ft. apart, and the car is about double that length, cylindrical in form, with pointed ends. It is intended, of course, not for the transport of passengers, but for carrying mail in small packages. As the car is pulled forward by the attraction of one of the solenoids, it shifts the current on to the solenoid immediately preceding, and so continues its motion. An oval track about half a mile long has been erected, and the speed of nearly 40 miles an hour has been already attained, with every prospect of doubling it when the track is levelled up and got into better condition. The amount of copper required is considerable, of course, each

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solenoid having about 20lb. of No. 14 wire upon it. The scheme is an ingenious one, but the cost of construction is rather forbidding.

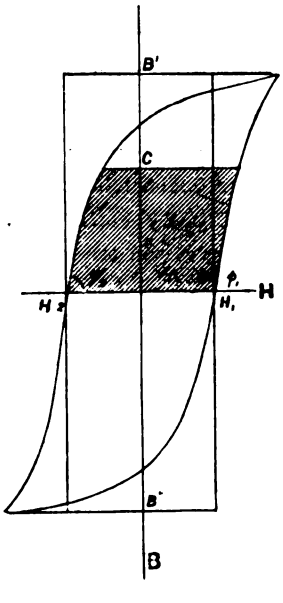
New Street Railway Motors.—Two or three new street railway motors are in process of evolution, the effort of the various inventors being to dispense as far as possible with gearing. The Wenstrom and Baxter Companies are each bringing out a motor which is geared but once to the driven axle, while a truck is under consideration which will be equipped with a pair of the remarkable Duncan motors of which something was heard a few months ago. This machine bids fair to work something of a revolution in electrical traction, for it gives a high efficiency with a speed which permits it to be placed directly upon the axle. It is not an "American novelty," but a very substantial, scientific, and business-like machine.

CORRESPONDENCE.

LOSS BY HYSTERESIS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your editorial notes last week you take exception to Mr. Tesla's statement that the loss by hysteresis, within certain limits, depends upon the square of the magnetomotive force. Mr. Tesla obviously means the limits within which the induction B may be considered proportional to H, in other words the approximately straight line parts of the permeability curves.



In the figure the straight line parts of the top part of a magnetic cycle of a closed circuit transformer are supposed limited by an induction b. Since in reality the angles ϕ, and ϕ_2 are nearly equal, the loss of energy for these parts of the cycle, represented by the shaded part of the figure, is nearly equal to $\frac{1}{4\pi}(H_1 + H_2)\,b$, so it is not at all proportional to the square of H, as stated by Mr. Tesla. This same formula may serve as a rough approximation of the total cyclic loss, E, or $E = \frac{1}{4\pi}(H_1 + H_2)(B' + B'')$, the error will generally not surpass 10 to 15 per cent.

In the case of open circuit transformers, H must be increased to get the same B as in a closed circuit one, the increase corresponding with the magnetic irresistance. The energy integral will now partly consist of a factor $\left[\frac{p B^2}{2}\right]$, p being a constant; for a complete cycle this factor becomes zero. Consequently the increase of H in an open circuit transformer has no effect on the cyclic loss.—Yours, &c.,

Amsterdam. G. L. F. PHILIPS.

TELPHER AND ELECTRIC RAILWAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We were somewhat astonished to read the strictures in your last week's issue on the purely descriptive paper we read before the Scottish Society of Arts on the telpher and electric railways of the Edinburgh Exhibition.

We must confess that the points referred to by you in your Notes fail to convey to us the deductions you make, and we believe will likewise fail with those of your readers who are at all familiar with the subject, either from a commercial or electrical point of view; indeed, we feel there is so little that requires serious refutation that we do not propose to occupy your valuable space with a lengthy reply.

We should, however, like to draw your attention to one or two of the points you refer to, which are not altogether in accord with the knowledge of the present state of the art.

We may state definitely that the only type of motor applicable to the satisfactory hauling of a telpher train is a series-wound motor. Surely you do not propose to tell us that any other method than stopping the supply of current to the motor could be used to prevent its tendency to indefinite acceleration; hence the existence of the Fleeming-Jenkin governor, or some other automatic equivalent.

It is news to us, indeed, that hanging a weight at the end of the stand rope adds to the complications of the line; on the contrary, it appears to our poor understandings as a simple and effective method of anchoring the rope, and one not likely to give any trouble in practical working. No doubt it adds vastly to the complications of the line to space the locomotives at definite distances apart, instead of letting them lie peacefully where they happen to come.

We are glad to be able to inform you that telpherage has advanced "beyond the toy stage," and is making progress perfectly satisfactory to the Electrical Engineering Corporation.

We think we were, perhaps, presumptuous in entering into commercial matters with which we may not be so well acquainted as with the technical portions of the subject; and here we may need correction, but we did think we were safe in taking the cost of maintenance in the United States on their electric tramways, where both labour and materials for maintenance are much higher in price than in this country, to compare with the cost of horse traction in this country, a large proportion of which cost is made up in labour at distinctly cheaper rates than in the States.

The energetic Council of the Edinburgh Exhibition can best reply to your last paragraph about the provision of the tramway line for the benefit of those interested in electrical traction. Strangely we thought that they were playing a very laudable part in bringing home to the minds of tramway directors in its proper place—an Electrical Exhibition—a cheap system of electrical traction applicable—we venture to re-assert eminently applicable—to small towns and country districts, which they could not be expected to adopt until they had examined it in actual operation.—Yours, &c.,

J. G. STATTER.
E. MANVILLE.

Princes Mansions, 68, Victoria-street, S.W., London,
October 22, 1890.

TRADE NOTES AND NOTICES.

[*Notices for insertion under the above heading must reach the Office not later than first post Thursday morning.*]

TENDERS WANTED.—The Streets Committee of the Commissioners of Sewers of the City of London notify that tenders are wanted for lighting by electricity the Western District of the City. Further particulars are given in our advertisement pages; and the conditions of the contract, which are similar to those arranged for the Eastern and Central Districts, may be seen at the office of Mr. H. Blake, Clerk of the Commissioners of Sewers, Guildhall, E.C. Tenders must be sent in to Mr. Blake not later than 2 o'clock on the 28th November next.

SALES BY AUCTION.—Messrs. Wheatley Kirk, Price and Goulty announce that the date of the sale, by public auction, of the high-class modern electrical plant, formerly the property of the

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City of Westminster Electrical Syndicate, upon the premises of the new Electric Supply Station, Eccleston-place, Eccleston-street, Buckingham Palace-road, S.W., has been fixed for Friday, October 31st, commencing at 11 for 12 o'clock prompt. The plant will be on view on Thursday, 30th October, and morning of sale. Particulars and catalogues can be obtained of the auctioneers, at either their London or Manchester offices.

SALES BY AUCTION.—Messrs. Furber, Price and Furber will sell by auction on the premises, 42, Eagle-street, Red Lion-street, on Thursday next, the 30th inst., at one o'clock, the electrical generating plant, including reservoirs, batteries, vats, lamps, instruments, &c., connected with the Perreur-Lloyd's system. Further particulars are given in our advertisement columns.

SURPLUS PLANT.—The Liverpool Electrical Supply Company announce that they have a quantity of surplus plant for disposal, particulars of which will be found in our advertisement columns.

THE BREWERS' EXHIBITION.—This Exhibition was opened on Monday last, and will close to-morrow (Saturday). We have again to chronicle the almost complete absence of any electric light display, which we have previously referred to in regard to the many Exhibitions which have been held at the Agricultural Hall, Islington. Messrs. Paterson and Cooper have a small installation of the electric light; Mr. Napier Prentice employs at Stand 175 a small motor for driving steam crushing machinery; and there is a 50-light Prentice dynamo at the stall of Mr. E. S. Hindley, who has a number of his well-known engines on view. Messrs. Crossley Brothers show a pair of engines, with the latest improvements. Amongst a number of other gas engines which may be mentioned is a new patent portable hydro-carbon gas engine, made by Messrs. S. Griffin and Co., of Bath, and shown at Stand 172. We may also mention the excellent exhibits of Messrs. Pontifex and Wood, and that of Messrs. Isler and Co. The latter firm has on view the new pumping engine and boring gear which the St. James and Pall Mall Electric Light Company are about to use to secure a good supply of water at their central station.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY (LIMITED).—We have just received the October Price List and Catalogue of this Company, which came into operation on the 15th inst. The Catalogue contains exhaustive tables of insulated electric light cables and wires (both indiarubber and vulcanised indiarubber), jointing material, wood casings, &c.

GENERAL ELECTRIC SUPPLY COMPANY.—We have received a copy of the fifth edition of the catalogue of this Company. It has been greatly enlarged, and contains 126 pages, with over 1,000 illustrations. It contains every possible requisite, including dynamos, switches, lamps, cables, cutouts, meters, engines, accumulators, and a very handsome selection of fittings, and instructions for tending a dynamo. We understand this Company have acquired the sole agency for the sale of the Crocker-Wheeler Motor, which is largely used in America.

MR. CARL OPPERMANN.—Mr. Oppermann announces his removal to larger premises, at 2, Wynyatt-street, Clerkenwell, London, E.C., where he has laid down plant for the construction of complete electro-plating fittings and dynamos for small installations.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

October 13, 1890.

16,264. H. CHITTY. Chiswick. Improvements in electro motors and dynamo machines.

16,272. R. L. B. RATHBONE. Liverpool. Improvements in or appertaining to globe or shade holders for incandescent electric lamps, in part applicable to other lamps.

16,278. F. WALTON and H. EDMUNDS. London. Improvements in electrical conductors.

16,279. U. SHAWIANOFF. London. Improvements in the process and apparatus for electrical casting of metals.

16,280. U. SHAWIANOFF. London. Improved means of preventing defects, such as blowholes and the like in castings by electricity.

October 14, 1890.

16,322. S. C. C. CURRIE. London. Improvements in insulating cells for electric batteries.

16,324. H. H. LLOYD. London. Improvements in the method of and apparatus for casting frames or supports for battery plates or elements.

16,346. S. C. C. CURRIE. London. The regulation and control of storage battery systems.

16,347. P. W. WILLIAMS. London. Improvements in electric clutches.

16,351. E. M. T. BODDAM. London. Improved mechanism for elevating and directing machine guns and electric light projectors from a distance.

October 15, 1890.

16,377. A. TURNER and A. E. LEVIN. London. Improvements in electrical cut-outs.

16,380. J. TATE. Bradford. Improvements in electrical apparatus for regulating the speed of engines, starting and stopping shafts, hoists, and other machinery.

16,415. M. W. DEWEY. London. Improvements in methods of and apparatus for utilising electricity in the formation of sheet metal articles.

16,416. M. W. DEWEY. London. Improvements in methods of utilising electricity in the formation of metallic cartridge cases and other articles.

SPECIFICATIONS PUBLISHED.

1889.

11,941. MIX and GENEST (Limited) and ANOTHER. Switch boards for telephone exchange. (Price 8d.)

18,261. HOOPER-RASTRICK. Joints for telegraphic, &c., wires. (Price 6d.)

18,821. GAERTNER. Electric baths. (Price 8d.)

18,939. HOLT. Railway, &c., vehicles propelled by electricity. (Price 8d.)

1890.

8,392. THOMPSON (Jacob Frères et Cie.). Conduits for electric cables. (Price 6d.)

11,466. FOOTE. Electro-magnetic friction clutches. (Price 11d.)

11,863. STRODE and GILL. Electric switches. (Price 6d.)

12,171. MOWER. Electric motor mechanism. (Price 8d.)

12,231. VAIL. Commutators for electrical machines. (Price 6d.)

12,634. FOOTE. Dynamo electric machines. (Price 8d.)

13,013. PEPPER. Electrodes for primary, &c., batteries. (Price 4d.)

13,344. ALLISON (Hathaway). Galvanic batteries. (Price 8d.)

13,485. WHITE. Electrical glow lamp conductors. (Price 6d.)

COMPANIES' MEETINGS.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The thirty-fourth ordinary general meeting of this Company was held on Wednesday, at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the last meeting, which were now approved.

The CHAIRMAN: Gentlemen, you have had the report in your hands for some days, and I presume you will take it as read; but if anyone desires to have it read that shall be done. The report is a full one, but nevertheless I shall follow my usual custom of going over some of the details, in order that our shareholders may have such information as may, I hope, increase their confidence in the working of this great submarine telegraph system. The gross receipts for the half-year amounted to £254,856, against £256,75 for the corresponding period of 1889, showing a decrease of £1,901. Our revenue for the past half-year has, in fact, been practically stationary. During the current half-year, however, the receipts show a considerable increase over those for the corresponding period of 1889. We are also benefiting from the recent substantial rise in the value of silver, as, instead of remitting our money home from India, China, and the Straits Settlements at a loss, which in 1889 amounted to as much as £11,000, we have lately made a small profit on exchange. We do not look upon this as permanent, for we are witnessing a phase of things respecting which time alone will tell us on which side the balance is likely to be. The working expenses have been £76,670, against £73,773 for the corresponding half-year, or an increase of £2,897. This is mainly accounted for by the cost of repairs having been heavier last half-year than in the corresponding period of 1889, and by the establishment of an agency at Melbourne. Part of the increased expense is also due to the new Roebuck Bay station. The net revenue has amounted to £136,675, against £138,736 for the corresponding half-year; showing a decrease of £2,061, due to the causes already explained. Two interim dividends at the rate of 5 per cent. per annum have been paid for the half-year under review, amounting to £62,500, leaving £71,820 to be carried forward. The laying of the duplicate cable between Australia and New Zealand, to which reference has been made on previous occasions, but more particularly at the last general meeting, has been successfully completed during the half-year, together with the partial renewal of the Madras-Penang section. The cost of these two operations, amounting to £269,281, has been debited to the general reserve fund, which, after being credited with £21,103, the profit made on the sale of investments, and £10,778 for interest received on investments during the half-year, now stands at £472,713. I have already explained to you that the great object of this Company is to maintain its system in a thoroughly satisfactory manner without increasing the capital. In that way we are enabled to maintain dividends which I trust are satisfactory to the shareholders, and at the same time to put by such an amount as will always be a reserve in case of such impor-

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tant works as those I have just mentioned becoming necessary. It will be seen from the revenue account that we have received a smaller amount of subsidy in respect of the Manila cable during the last six months than in previous half-years. This is owing to the subsidy arrangement having expired in May last; but as all the Five per Cent. Debentures issued to provide the capital for the Manila cable are now paid off there will be no further contributions required for the interest and sinking fund; and in future, therefore, there will be a saving effected on this account of about £5,000 a year. I referred even as far back as two years ago to the question of the redemption of the Six per Cent. Debentures, and the time is now drawing near when these Debentures will, I hope, be changed into Perpetual Debenture Stock, bearing 4 per cent. interest. We prefer this method of paying off the Six per Cent. Debentures to taking the money from the Reserve Fund. We hope, therefore, to issue this amount of Perpetual Debenture Stock at 4 per cent., while the holders of the ordinary stock will be receiving 6 to 7 per cent. The operation, therefore, is a good one, and at the same time it will not increase our capital in any way. The revenue will benefit to the extent of £6,000 per annum by the saving that will be effected by issuing Four per Cent. Mortgage Debenture Stock, in place of the Six per Cent. Debentures, which fall due on February 1st next. The necessary resolution authorising this issue will be submitted at the extraordinary general meeting to be held at the conclusion of the present meeting. With reference to our cable renewals, the policy of strengthening the system without adding to the capital has been continued during the half-year, when, in addition to the partial renewal of the Madras-Penang cable already referred to, 67 nautical miles of cable were inserted in the Tonquin-Hong Kong section, which has given trouble of late, and is at present interrupted; and the operation will be continued as opportunities occur until the line is put into thorough order. This is another instance showing the necessity of duplicating our system, so that our income may not be disturbed; for when one cable is interrupted, in nine cases out of ten the other is working, and our revenue is maintained. Although the Company's maintenance ships have been employed on various cable repairs during the past six months, no interruptions materially affecting revenue have occurred. Since the close of the half-year, however, Australia has unfortunately been cut off from telegraphic communication for nine days, owing to the sudden and simultaneous interruption, through volcanic action, of the Company's three cables between Java and Australia, near Banjoewangie (Java). The three cables were interrupted at the same time; but owing to a cause that has rarely occurred. In fact, only two interruptions from volcanic causes have previously happened on the Company's system during a period of nearly twenty years. However, this occurrence only again shows the importance of duplicating the cables, for in this case, as I have said, we had three cables, and they were all interrupted. It is in one sense a misfortune, but not so in another. It is a great satisfaction to know that we can effect the repairs quickly and thoroughly, and to know that any Company having only a single line could not live or compete with us. That is our strength. We are not monopolists; we have no exclusive concessions; but we have so fortified ourselves by having such an abundant supply of carrying capacity, that we consider ourselves in a tolerably sound position. A matter that has been a great deal talked about of late, especially during the last six months, is the question of reduced tariffs to Australia. Our present tariff is 9s. 4d., to which we reduced it five years ago from 10s. 8d. Three years since we recouped the loss we thus made, and then another agitation began for a further reduction. We had several conferences with the Agents-General of these Colonies in London, who are all men eminently qualified to look after the interests of their Colonies, and submitted a proposal for attaining the desired object. We believe in the vitality of the traffic, and that the merchants who now spend thousands a year in telegraphing will continue to do so; and probably increase their expenditure if the rates are reduced. Our proposal was to test the effect of a substantial reduction in the rates under a Government guarantee, and was submitted to the Australasian Governments, backed by the support of the Colonial Agents. The result was that a conference was held in Adelaide, at which a resolution was passed adopting the proposal. We are now in course of negotiating with the Colonial Governments. Some of the colonies think that the Home Government should have taken a part of the responsibility; but, for reasons best known to the latter—and probably in the long run, wise reasons—the request was declined. My impression is that they will act independently of the Home Government, and I think the probability is that before I address you again, six months hence, we may be able to tell you that these negotiations have been successfully completed. If so, the result will be that we shall have a 4s. tariff instead of 9s. 4d.; but we shall have the guarantee of the Colonial Governments to make up half the amount of money with the 4s. tariff that we receive at the present moment. We are taking the other half of the risk of any loss that may be incurred, and we feel that we are justified in doing so, for the reasons I have already mentioned, namely, the vitality and competition for business in the Colonies, and the belief that we entertain that the merchants will not only continue, but will materially increase the expenditure on telegraphic messages. In that case the result will be that we shall get our present income, and the value of our property will be increased by the guarantee of the Colonial Governments. Looking at the present state of the negotiations, the favourable view which the Colonies take of our proposal, and the more favourable view which the press of the Colonies take of it, we feel pretty confident that we shall see this matter carried through. It would be a new departure in telegraphy that would create an enormous change. I may add that if we had not fortified ourselves by duplications we could not have undertaken to carry the increased traffic which the reduced rates are likely to bring about. As it is, we have the cables ready to be employed, and we have practically paid for them. The last time I addressed you reference was made to the Conference which was to be held in Paris, and a great deal was said as to these Conferences being a serious business for the Cable Companies. I told you then that we should do the best we could for the Company, and I am pleased to tell you that we did not suffer unduly. We did all we could to make the Conference pass off well. Before going to the Conference we had several interviews with the Indian Government Delegate. The Governments are beginning to realise that we are something more than an ordinary combination—that we are not only a great power for bringing the nations of the world so closely together, but that we are a power with whom they have to reckon, and we think they are disposed to reckon with us on fair terms. Before going to Paris we had several interviews with the Indian Government delegate, and our relations with the Indian Government were very much strengthened through what passed at those interviews and at the Paris Conference, the result being that satisfactory arrangements were concluded for reductions in the Indian transit and terminal rates, and for generally improving the international service. These arrangements include the duplication of the Madras-Penang cable, a contract for which has been entered into with the Telegraph Construction and Maintenance Company; and the abolition of our Elephant Point station at the mouth of the Rangoon River, the existence of which had long been threatened by the rapid encroachments of the sea at that place during the last few years. I will now conclude by proposing the following resolution:—

"That the report and accounts of the Directors now submitted be received and adopted."

Mr. F. A. BEVAN: I have much pleasure in seconding the resolution.

The CHAIRMAN: If any shareholder desires to make any remarks on what I have said or on the report, I shall be happy to hear him.

Mr. JOHN NEWTON: It is very satisfactory to see that you are going to pay off these Six per Cent. Debentures, and that you can now issue Four per Cent. Stock. Still you are now mortgaging our property, and as a shareholder I object to the mortgaging of any of our property. I think it would be better to issue ordinary shares and pay off your mortgage. You would have a stock then which would have a freer market, on account of their being more of it. I think your experience of Conferences have been this—though you have got out well from the last one—that when you get up to a 7 per cent. dividend, those attending the Conferences say that that return is too much to pay to your shareholders, and they knock down your tariffs so as to reduce your dividend. It seems to me that, however friendly Governments may be to you, they do their best to prevent your paying a substantial dividend, which shareholders in telegraph companies are entitled to, seeing the enormous risk they underwent when they first took part in these enterprises. I think, with the force that is behind you, which takes away your revenue from you because they consider that your tariffs are too high, it would be better to issue the balance or a portion of the unissued amount of your shares. You could do that and obtain a premium of 2 on them, which would give you a substantial sum to add to your reserve fund. Besides, the Four per Cent. Debenture Stock will be a first charge on your property, and in the event of a difficult time coming you have not that security to offer. You will be creating a first-class security when it is not necessary to do so, and it will increase your ordinary revenue. You will then have to reduce your profits. Those who belonged to this Company at the outset must have seen with surprise what you can now do; but the ordinary shareholders are not getting the benefit of your progress.

Mr. SAMUEL SMITH: Do you not think that this is a question which ought to be raised at the extraordinary general meeting?

The CHAIRMAN: Yes, you are quite right.

Mr. SMITH: I wish to ask the nature of the guarantee which the Australian Governments will give us in respect of the proposed change in the tariff, and also whether the Colony of New Zealand, to which we have been so liberal, will take part in the guarantee.

The CHAIRMAN: I think we had better discuss Mr. Newton's question when we come to the extraordinary general meeting. As to the question about the guarantee, I suppose that any one of us would be delighted to take as a guarantee the resolution of the Parliaments of the Colonial Governments. As to New Zealand joining in the proposed arrangement, we are negotiating with the Government of that Colony. So far New Zealand has stood apart from the other Australian Colonies. I cannot tell you all that I might about this matter; but when these negotiations are carried through, it will, I believe, be so much for the interest of New Zealand to take part in it that I have no doubt myself that she will do so.

A SHAREHOLDER: Will you tell us where the three cables were broken, and at what distance from each other the breaks occurred?

The SECRETARY: Near Banjoewangie. It is stated in the report.

The CHAIRMAN: The breaks all occurred at the same instant.

The SECRETARY: Within a few miles of each other.

The CHAIRMAN: As I have already pointed out, this is an occurrence we need not anticipate every day. He then put the resolution to the meeting in the usual manner; and having declared it carried unanimously, said: We now come to the special meeting; and the Secretary will read the resolution to be proposed.

The SECRETARY thereupon read the following resolution, viz.:—

A. "That the Board of Directors be, and are hereby authorised from time to time to create and issue Mortgage Debenture Stock of the Company to an amount not exceeding one-third of the share capital of the Company for the time being issued and paid up, upon the terms that the aggregate amount of the said stock for the time being in issue, and the interest thereon, shall rank pari passu *as a first charge on the undertaking and revenue of the Company, the stock to be issued at such times, in such amounts, and on such terms and conditions as the Board shall from time to time determine, for the purpose of redeeming, by exchange or otherwise, the outstanding Debentures of the Company, or any other purpose to which the capital of the Company may be lawfully applicable.*

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B. "That the Board be and are hereby authorised to make such provision as they think fit for the registration and transfer of Mortgage Debenture Stock, and for the delivery of certificates thereof, and for the payment of the interest thereon, and generally as to the form and incidents of all documents relating to the said stock, but so that no such provision be inconsistent with paragraph A of this resolution."

The CHAIRMAN: I propose that resolution, and I think I may now reply to Mr. Newton. We do not admit of sentiment coming into our calculations in dealing with this question. I think that every man enjoying private property will sleep more soundly and be happier if he has no mortgage on his property; but here are we, a company with our capital of £2,500,000, and all the mortgage we have on it at the present moment is this £320,000. Now would it be wise on the part of your Board to pay 7 per cent. on that portion of the capital, instead of 4 per cent.? I think you will all agree with me, looking at this insignificant sum, and remembering that this Company must continue to exist and roll on, that this £320,000 is but a bagatelle compared with the large capital that we have.

A SHAREHOLDER: And the reserve fund.

The CHAIRMAN: Yes. We might if we choose use that reserve fund and pay off this amount, but would it be wise to do so? I think myself that it would be a very unwise proceeding to do that. I look upon this £320,000 as a sum that does not in the slightest degree interfere with us; but still, as I stated a little while ago, by paying off the Six per Cent. Debentures we are saving £6,000 a year, which the general body of shareholders will get the advantage of. I am quite sure that Mr. Newton will agree with us if he thinks the matter out, and puts the little sentiment aside, in which, however, he is quite right. The fewer mortgages people have the better, but this is a mortgage that I should think rather ballasts the ship than lightens it; and I think it would be best to pass the resolution which has been read, seeing that the saving effected by it for the Company will be £6,000 a year.

Sir JAMES ANDERSON: I beg to second the resolution.

A SHAREHOLDER: It seems to me that Mr. Newton's objection, as far as the present shareholders are concerned, would to a very large extent be obviated if the Directors were to issue this Debenture Stock to the present shareholders. Then any shareholder who might feel that his position was injured by the issue of this Debenture Stock would be able to fortify himself by taking up his proper proportion of Debenture Stock.

The CHAIRMAN: That is exactly what we are going to do. The suggestion is a very proper one. We think this Debenture Stock is a good security, and the shareholders will all have the first offer of it.

A SHAREHOLDER: The shareholders will have the option of subscribing for it?

The CHAIRMAN: Yes. We have always given the shareholders the first option. I have not the slightest doubt that the stock will all be taken up.

A SHAREHOLDER: Will the present holders of the Six per Cent. Debentures have any preference?

The CHAIRMAN: We do not know who they are. We recognise our shareholders first. If any applications come from those who hold the Debentures now, they will come in for their proportion of this stock after the shareholders are satisfied.

Mr. SMITH: As an ordinary shareholder, I am entitled to my proportion; but I have had the gratification of receiving 6 per cent. for my money in the existing Debentures for 15 years, and I am very sorry to lose that. (Laughter.)

Mr. NEWTON: It does remove a certain amount of my objection when I hear that you are going to give the ordinary shareholders a priority over the holders of the existing Six per Cent. Debentures to take up this stock. I held Seven per Cent. Debentures in a telegraph company. They paid them off, and issued others bearing 6 per cent., and then they paid those off and issued Five per Cent. Debentures, but the holders were not entitled to have the new Debentures in priority to the shareholders. It does remove the objection I had from the point of view that I can take some of this stock if I like; but it does not remove what I said, that the Governments do come in if you advance your dividend to anything like 10 per cent., which I expected in a telegraph company; and it was a reasonable expectation to look for, but the moment you come to 7½ per cent. you are stopped. I see by this saving you will make £6,000 a year, and the saving you make by the redemption of Debentures you will get 7 per cent., and then you will have a strong attempt made at the next Conference to put down your tariffs. It is very satisfactory to see from this proposed arrangement with the Australian Colonies what you can do. If you issued your ordinary shares at 2 premium a dividend of 7 per cent. would not be a dividend of 7 per cent. on the capital as it would be on £12 and not £10. I recognise, and I think the Directors ought to recognise, the fact that the capital in this enterprise is represented in two ways. One is in capital and the other is in reserve, and the latter is what is represented on the Stock Exchange. When I take the capital value of my shares here I do not do so at £10, because if I sell a share I can get more than £10 for it.

The CHAIRMAN: It is not often that a chairman has to argue with a shareholder who is opposed to a high dividend. I rather think, Mr. Newton, that the time was when I thought 10 per cent. was the lowest rate we ought to have got in our submarine system. I may quote Mr. Newton again, for at a meeting not long ago he said that a 7 per cent. dividend now was as good as 10 per cent. a few years ago, such is the change in the value of money, and I think Mr. Newton will admit that to-day. Paying now 7 per cent. and putting by such a reserve as we are doing, not adding to our capital, but adding to the strength of the Company enormously by putting down new cables, I think we are showing a system of management, which, if all Companies were conducted on the same principle and had the same results, would cause them to hold a very proud position; and in our own case the test of that position is the very fact of our being able to issue this Four per Cent. Debenture Stock, as I feel sure we shall be able to do. It shows the position we occupy in the Money Market. If, after all, our property is at the bottom of the sea, still, we know where it is, and we know how to get at it and mend it if necessary. You can all take your share of this stock, every man according to his holding. We shall issue a notice to every shareholder, and shall tell him what his *pro rata* share is. If he wants any more he can say so; and then after the shareholders are satisfied according to their holdings, there will be an appropriation again. I thank Mr. Newton for his suggestion; and I now put this motion, and I do so in the thorough belief that it is a good thing for the Company, effecting a very material saving for the Company, and that you will receive it with acclamation. He then put the motion, and declared it carried unanimously. There must be another meeting of the shareholders within a month to confirm this. I do not think it will be necessary to go to the expense of engaging a room for that meeting, but purpose holding it upstairs in our own office.

Mr. NEWTON: I propose a vote of thanks to the Chairman and the Directors for the way in which they have safeguarded our undertaking. I hope they will preserve a steady dividend, and not let the Conference reduce our tariff.

A SHAREHOLDER: I have the greatest pleasure in seconding the resolution.

The resolution was carried unanimously.

The CHAIRMAN: I am very much obliged to you, and I thank you on behalf of my colleagues and myself. I only regret that my voice has been so bad to-day, or I might have made the strength of our position clearer. I appreciate your kindness, and your appreciation of the work we have been doing for you in the last few years.

The proceedings then terminated.

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Brazilian Submarine Telegraph Company (Limited).

The thirty-fourth ordinary general meeting of the shareholders of the Brazilian Submarine Telegraph Company (Limited) was held at Winchester House, Old Broad-street, on Wednesday, under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the last general meeting, and the report of the Directors was then taken as read.

The CHAIRMAN said that a very short cursory observation of the report and accounts showed that they had nothing except what was satisfactory to report with respect to the actual working of the past half-year. They paid a dividend of 7½ per cent., added £40,000 to the reserve fund, and had paid off debenture debt to the amount of £15,300; and he might add that the receipts of the current half-year, as far as known, justified them in expecting that they would be in a position to do as well in this half-year. The receipts of this half-year were considerably larger up to this date than they were at the same period of last year. However, notwithstanding these satisfactory evidences, they had undoubtedly a rock ahead in the termination of their Brazilian concession, which ends in about two years, and that from the Portuguese Government in about four years. Many things were being done with reference to this event, and he could only assure the shareholders with respect to it that the Directors were watching with the utmost vigilance to maintain the shareholders' interests when the time for proper action arrived. At the last general meeting some observations were made with reference to statements in the original prospectus of the Company. That was a subject upon which he was rather sensitive, because he was then as now chairman, and, of course, was responsible for anything which was stated in the prospectus. He had not a word to say against the disposition of the gentleman who made these observations, for he exhibited the utmost good feeling towards the Directors in reference to the management by the latter of the business of the Company. The gentleman in question, however, said, and said truly, that there were statements made with reference to a yield of probably 14 or 15 per cent. What was done in connection with this matter was this: they endeavoured to establish relations between the general mercantile movements in the country and the telegraphic communications to which they gave rise. They did this on the experience of others, and he did not think they would disagree from him when he said that that was not a bad way of ascertaining what their profits might be from the experience of others. The Board stated from that experience—from the figures then open to all to whom the prospectus was addressed—that the trade from and to South America might be expected to yield 15 per cent. That meant the general yield—not merely the net profit to be derived from the transactions, but the general yield which the traffic would give. It had not yet arrived at the point to which they referred, but it was very nearly approaching to it; and he did not think when they considered what had been done in the Company that their management would be regarded as in any way objectionable. During the period they had been in existence, which was now 16 or 17 years, they had paid dividends never less at any time than 5 per cent., on many occasions they had been 6, 7, and 7½ per cent. They had duplicated the whole of the system principally out of revenue, and if the balance of the sum of the Debenture Debt, raised for the purpose of the duplication, were now paid off, they would still have in hand a sum of £200,000 for reserve. He did not think if they consulted shareholders in other similar Companies that they would be told that the management of this Company had been defective. Their plant was in excellent order, and the lines were all working well. The receipts for the half-year of June, 1890, showed an increase over those of the previous half-year of £755. The general expenses in London exhibited a decrease of £213, which was accounted for by the absence of special law charges, which were less this year than last year by £235. The working expenses of the stations showed a decrease amounting to £696. The total expenses exhibited an increase of £1,291, which was more than accounted for by the laying of six new land lines at Pernambuco, costing £1,907. This, however, was an extraordinary item of expenditure which was not likely to occur again. Since their last meeting Dr. Taylor, who had been their Director in Brazil, had died, and they had now appointed Senhor Andrade Pinto as their representative there. Senhor Pinto is the son of the gentleman who was formerly the Company's Director there, and he believed he would be found of great use to them. At the Paris Telegraph Conference their Company was represented by Sir James Anderson and the Managing Director. He concluded by moving the following resolution:—

"*That the Report of the Directors and the accounts to June 30, 1890, now submitted, be approved and adopted, and that a dividend be now declared of 3s. per share (making, with the interim dividends already paid, a total dividend of 6 per cent. for the year ended June 30, 1890), and also a bonus of 3s. per share in respect of the profits for the year ended June 30, 1890, the said dividend and bonus to be respectively free of income tax.*"

The VICE-CHAIRMAN (Sir James Anderson) seconded the resolution, which was adopted unanimously.

On the motion of the CHAIRMAN, seconded by the Hon. W. St. JOHN F. BRODRICK, M.P., Sir James Anderson was re-elected a Director of the Company, as was also Mr. Frederick Youle, on the motion of the CHAIRMAN, seconded by the MANAGING-DIRECTOR (Mr. Thomas Fuller).

Dr. TREWHELLA then proposed and Mr. C. S. HAWKES seconded the re-election of the auditors, Mr. Henry Dever and Mr. John Gane.

Captain BLAKEY, R.N., afterwards proposed a vote of thanks to the Chairman and the Directors for the admirable way in which they had managed the affairs of the Company.

Dr. TREWHELLA seconded the motion, which was unanimously adopted.

The CHAIRMAN acknowledged the vote; and assured the shareholders that the Directors would combine to do their utmost to promote the welfare of the Company.

The proceedings then terminated.

Direct Spanish Telegraph Company (Limited).

An extraordinary general meeting of this Company was held at the offices, Winchester House, Old Broad-street, on the 21st inst., under the presidency of Sir James Anderson, for the purpose of confirming the following special resolution passed at the extraordinary general meeting held on the 30th ult:—

"*That Article 71 of the Articles of Association of the Company be and is hereby repealed, and instead thereof the following be a regulation of the Company:—*

"*The Directors shall receive, as remuneration for their trouble in the execution of their office, the sum of £600 per annum, or such other sum as the Company in general meeting may from time to time determine, and such remuneration shall be apportioned by the Directors among themselves in such manner as they shall from time to time think fit.*"

On the motion of the CHAIRMAN, seconded by Mr. LEWIS WELLS, the resolution was unanimously confirmed.

A vote of thanks to the Chairman closed the proceedings, which were purely formal.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended October 17th amounted to £1,891.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY.—This Company has declared an interim dividend for the past half-year at the rate of 5 per cent per annum, payable on the 14th prox.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ending October 17, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,842.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).—The Directors of this Company will, at the forthcoming meeting of the shareholders, recommend a payment of 6s. per share to June 30th last, on the First Preference Shares of the Company, and £3 per share on account of arrears on the Second Preference Shares. £1,500 is placed to the reserve fund, and £322 carried forward. The meeting of the shareholders will take place early in November.—The receipts of this Company for the half-month ended October 15th amounted to £2,887, as compared with £2,064 in the corresponding period, an increase of £823.

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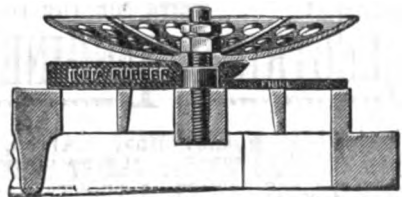

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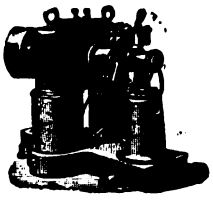
COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 15.		Price Wednesday, Oct. 22.		Rate per Cent. Yielded.	Dividend Due.	Business Done during Week Ending Oct. 22.	
								£ s. d.		Highest.	Lowest.
			TELEGRAPHS.								
1,331,390	Stock	15/0	Anglo-American ..... xd	49½	50½	49	50	..	Jan., Apr., July, Oct	50½	49½
2,809,310	Stock	30/0	Do. Preferred ..... xd	85	86	85	86	6 13 9	" "	86½	86½
2,809,310	Stock	..	Do. Deferred ..... xd	13⅝	14½	13½	13⅝	..	" "	14⅛	13⅝
25,000	£100	4%	African Direct, 4 per Cent. Debentures	98	101	99	102	3 18 5	January and July ..	99	..
130,000	10	3/0	Brazilian Submarine	11⅜	12⅛	11⅜	12⅛	5 6 1	Mar., June, Oct., Dec.	12 1/16	11⅛
69,200	100	5%	Do. 5 per Cent. Bonds	100	102	100	102	4 18 0	January and July ..	..	..
75,000	100	5%	Do. 5 per Cent. Bonds (2nd Series)	103	107	103	107	4 13 6	June and December	..	..
$7,216,000	$100	..	Commercial Cables	102	104	102	104	..	..	..	..
£16,000	£10	8/0	Cuba Submarine	11½	12	11½	12	7 1 8	February and August	..	..
6,000	10	10%	Do. Preference 10%	17	18	17	18	5 11 1	" "	..	..
12,931	5	2/4½	Direct Spanish (£4 paid) ..... xd	3⅜	4½	3⅜	4½	5 12 11	March & September	4	3⅜
6,000	5	10%	Do. Preference 10%	9	10	9	10	5 0 0	April and October ..	..	..
60,710	20	8/6	Direct United States	10⅜	10⅝	10⅜	10⅝	6 11 9	Jan., Apr., July, Oct.	10⅝	10 7/16
400,000	10	2/6	Eastern ..... xd	13½	14½	13½	14½	4 12 0	" "	14½	13⅝
70,000	10	6%	Do. 6 per Cent. Preference ..... xd	14½	15½	14½	15½	3 18 8	" "	14⅝	..
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.....	104	107	104	107	3 14 9	May and November	..	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106	109	106	109	4 11 9	February & August	..	..
250,000	10	2/6	Eastern Extension ..... xd	14	14½	14½	14⅝	4 17 5	Jan., Apr., July, Oct.	14½	14½
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100	102	100	102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austin. Gov. Sub.) Debs. 1900	102	105	102	105	4 15 3	January and July ..	101½	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	101	104	101	104	4 16 2	" "	..	..
180,227	10	1/9	Globe Telegraph and Trust ..... xd	8⅜	9	8⅜	9	5 8 4	Jan., Apr., July, Oct.	9	8⅛
180,042	10	6%	Do. 6 per Cent. Preference ..... xd	14⅛	14⅜	14⅛	14⅜	4 1 4	" "	14⅜	14⅛
150,000	10	5/0	Great Northern	15⅝	16⅛	15⅝	16⅛	4 12 4	Jan., April, and July	16⅛	15⅝
15,000	100	5%	Do. 5 per Cent Debentures, 1881	101	104	101	104	4 16 2	January and July ..	..	..
210,000	100	5%	Do. 5 per Cent. Debentures, 1883.....	104	107	104	107	4 13 6	March & September	104	..
17,000	25	37/6	Indo-European	36	38	36	38	6 11 7	April and October ..	..	..
38,348	10	4/0	London Platino-Brazilian	6½	7⅛	6½	7⅛	5 6 8	..	..	..
120,000	100	6%	Do. 6 per Cent. Debentures	105	108	105	108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's ..... xd	8½	8⅝	8½	8⅝	5 14 4	April and October..	8½	..
3,381	£100 Cert.	6%	Submarine Cables Trust ....x April Coupon, 1890	110	114	110	114	5 5 3	" "	..	..
15,609	£10	6/6	West African	8½	9½	8½	9½	5 5 3	..	..	..
220,000	100	5%	Do. 5 per Cent. Debentures	98	101	98	101	4 19 0	March & September	..	..
30,000	10	3/0	West Coast of America	4½	5	4½	5	10 0 0	January and July ..	4⅝	4½
150,000	100	8%	Do. Debentures 8%	102	107	102	107	7 9 7	June and December	103⅝	103
88,321	10	Nil.	West India and Panama	2⅞	3⅛	2⅞	3⅛	..	..	3 1/16	3
34,563	10	6/0	Do. 1st Preference 6%	11½	12	11½	12	5 0 0	April and October..	12⅛	11½
4,669	10	27/6	Do. 6 p. c. 2nd Pref.....	14	15	14	15	4 0 0	..	..	..
61,572	15	6/0	Western and Brazilian	11⅛	11⅜	11	11⅛	5 4 3	May and November	11⅜	11⅛
21,986	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6⅜	7⅛	6⅜	6⅞	..	..	6⅞	6⅜
21,986	7½	4/6	Do. 5 per Cent. Deferred	4⅜	5⅛	4⅜	5	..	..	..	..
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103	106	103	106	5 13 2	..	..	..
250,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	103	106	103	106	5 13 2	February & August	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	122	127	122	127	5 10 3	May and November	..	..
£175,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99	103	99	103	5 16 6	March & September	..	..
			TELEPHONES.								
224,850	14/0	0/5½	Consolidated Telephone Const. and Maintenance..	⅛	¼	⅛	¼	..	Yearly	..	..
220,000	£1	3%	Oriental (11s. paid)	7/16	⅜	⅜	⅜	4 8 3	Yearly	..	..
436,700	5	3/0	National	4¼	4⅜	4¼	4⅜	6 13 4	June and December	4 5/16	4 7/32
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12¼	12½	12	12½	4 16 0	June and December	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	10	10½	9½	10½	5 14 3	" "	..	..
209,750	1	⅛%	South of England, Ordinary	⅛		⅛		..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd)..	2½	3	2½	3	..	..	..	..
55,000	5	1/0	United River Plate	3⅜	4	3	4	..	January and July ..	..	..
146,000	Stock	5%	Do. 5 per Cent. Debenture Stock	90	94	90	94	5 6 5	..	..	..
100,000	100	7%	Do. 7 per Cent. Debentures	..		..		..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.								
555,000	£5	..	London Electric Supply	2⅜	2⅝	2⅜	2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£8 paid)	5½	6	5	5½	..	..	5½	5⅜
42,853	5	..	Westminster Electric Supply (£3 paid)	2⅛	2⅜	2⅛	3	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.								
63,416	3	..	Brush Electrical Engineering	1½	1⅝	1½	1⅝	..	..	1 7/16	..
63,416	2	0/10	Do. 6 per Cent. Preference	1½	2	1½	2	6 0 0	..	..	..
20,000	5	7%	Crompton and Co., 7 per Cent. Pref. Shares	5½	5⅝	5½	5⅝	6 1 9	..	..	..
353,478	5	..	Edison and Swan United	..		..		..	..	..	..
409,000	10	..	Electric Construction	7½	8	7½	8	..	..	7⅜	..
46,700	2	10/0	Elmore's Patent Copper Depositing	5	5½	5	5½	..	..	5⅜	4⅜
20,000	5	..	Fowler-Waring Cables (£4 paid).....	2½	3½	2½	3½	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	18½	19½	18½	19½	5 2 7	February & August	19	18 7/16
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	100	102	100	102	4 8 3	..	..	..
78,949	5	6%	Swan United (£3. 10s. paid)	5½	5⅝	5½	5⅝	3 12 11	..	5½	5½
37,350	12	12/0	Telegraph Construction and Maintenance.....	43	45	43	45	5 6 8	March and July.....	45	44
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894.....	100	102	100	102	4 18 0	..	..	..



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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 650.—Vol. XXV. FRIDAY, OCTOBER 31, 1890. Price Fourpence.

NOTES.

We are glad to be able to announce that the City and South London Railway will be opened on Tuesday next by the Prince of Wales, thus disposing once for all of the many rumours of hitches, for which at no time was there any genuine foundation. Although several years have elapsed since the line was commenced, the work has progressed as fast as is possible where so many contractors are employed. For some time past the engines and dynamos have been in regular work, ten electric locomotives having been delivered, while four more will shortly arrive. The carriage-sheds, when we visited the works last week, were full of rolling-stock in a complete state, and the stations were being painted, nearly all the structural work being finished. A mere glance at the immense lifts, the stations and their fittings, the signal-box at the western terminus with no less than 24 levers, was sufficient to show us that the work is on a scale which removes it from comparison with any mere tramway work. No precaution has been neglected to ensure regular service when once the line comes into operation; trains have been running frequently in order to accustom the staff to the work, and every appliance connected with working of the system has been thoroughly tested.

Another step will be made in the progress of the electric lighting of London next week, by the closing of the central station at the Grosvenor Gallery, and the transference of the work to what Dr. Fleming calls the eccentric station at Deptford. We have within the last few days heard of the Ferranti mains spoken of as though they were still in an experimental stage, and have been asked whether any satisfactory method of making the joints has yet been discovered. The fact is that when a short length on one of the bridges has been completed, no less than 30 miles of Ferranti main will be actually laid. Of upwards of 8,000 joints, only 15 have been found to be faulty. Several of these have been due to no electrical difficulty, but to the carelessness of the men in forgetting to remove the cotton waste from the socket end. There has been but one single fault from the inner to the outer conductor, and this was due to moisture.

Those who were unwise enough to prophesy before they knew, said that the joints which are made with a plug in the inner tube, and a sleeve burnished or rolled down on to the outer conductor, would offer a considerable resistance, on account of imperfect contact and the absence of solder. It may interest these prophets to learn that the calculated resistance of the mains was 2·16 ohms, and the actual measured resistance is 2·2 ohms. The mains on one occasion were warmed up by a huge current, and as many joints as were accessible were felt, but no difference whatever could be detected. Immediately after this test, a pressure of 20,000 volts was put on without disclosing any defect.

The question of the choice of "Lighthouse Illuminants" would not appear at first sight to have any more important side than that of the beneficent philanthropy which guides the mariner to the haven and warns him from the hidden rocks and sands. But, strangely enough, this very question has given rise to contentious discussions, and quarrelsome controversies; it has allowed eminent scientific men in their wrangles and wordy altercations to lose sight of the humane ends in view, and to reveal a pettiness no less surprising than deplorable. It is to be hoped that the report which has been presented to the Board of Trade by the President of the Royal Society and two of his most distinguished colleagues will bring back the matter to a simply scientific issue; and that their verdict, together with the report of Trinity House which they have confirmed, will be taken as conclusive.

That electric light would be proved by the North Foreland tests to be superior to oil or gas was an issue which found no excited advocate, nor was the cause supported by the use of modern machinery. Patentees of gas and oil lamps brought out their latest improvements, but the electric current was generated by the de Meritens machines, which if not still used in a few lighthouses, would have long ago been obsolete. The fact that the rays of higher refrangibility in which the light of an electric arc is so rich are the first to be cut off by a fog, is counterbalanced by the enormous quantity of light initially given out by the apparatus; and it is further to be remarked that the residue of yellowish rays which have succeeded in passing through a haze are well qualified to continue their course, and are on a fair footing with those emitted from a gas or oil lamp.

Sir George Stokes, Lord Rayleigh, and Sir William Thomson state that an arc light is at a disadvantage compared with gas or oil lamps since the angle in a vertical section of the beam must be sufficient to allow the light to strike the sea from the horizon of the lighthouse to a

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point at a moderate distance from its base; and they observe that the angle of the beam from an arc is less than that of an oil or gas burner, since the luminous area is smaller. It appears to us that this is the fault of the optical apparatus rather than of the source of light. Not only can lenses be readily designed to give any desired angle, but the electric beam should be far more uniform than that of a large flame, or rather a group of flames, since they cannot all be brought into the focal plane or planes. Every ray of light that (after allowing for refraction) passes above the horizon is wasted. The clean cut beam from an arc could be arranged to fall just where it is wanted with little or no scattering above and below the useful angle.

It is with regret that we learn that the Bristol-road electric tramways at Birmingham are already in difficulties; but it does not appear that the electrical part of the work is at fault. The lines are laid in wood pavement of an inferior description, and with every change of weather the gauge varies. This, of course, puts a severe side pressure on the wheels, and entails a great expenditure of power. Some idea of the strain to which the cars have been subjected may be obtained from the fact that strips of steel have actually been torn by the wheels from the new steel rails. The Jarman car at Clapham has experienced similar difficulties. There the gauge has not altered, but the rails are too narrow in the groove, and the wheels being too light to stand the strain have repeatedly broken. We understand that these rails have occasioned similar accidents with the horse-cars. These unfortunate mishaps do much mischief to the cause of electrical traction, since the public only see the breakdowns, and find the service disorganised. Nor can they be expected to inquire whether the causes are mechanical or electrical, and they are justified in expecting that the engineers in charge of the business should be competent to look after both departments.

We publish this week an article by Mr. Blakesley, in which he shows how to determine the energy lost in electro-magnetic cores, when alternating currents are traversing the coils. The process consists of an ingenious modification of Mr. Blakesley's well-known method for finding the difference in phase of two alternating currents by the use of three dynamometers; and the energy wasted in the core is expressed in terms of the lag between the two currents.

Many meanings have from time to time been given to the phrase "magnetic lag." Mr. Blakesley apparently only uses the term to represent the difference in phase between the curves representing the magnetisation of the core, and the exciting current flowing in the coil. We need not enter into Mr. Blakesley's views regarding the cause of magnetic lag, since they are debatable; it suffices to say that whenever hysteresis occurs with alternating currents, such a difference in phase must exist, and, further, if energy is lost in Foucault currents the lag must be correspondingly increased. Mr. Blakesley assumes that the currents vary with the time in the manner represented by a sine curve. This postulate has often been criticized, and may be compared with the predetermination of steam-engine diagrams by drawing adiabatic or other assumed lines. That it is sometimes far from being the case, a reference to the Paper of Messrs. Humphrey and Powell, printed in *The Electrician* for July 18th last, will readily show. Measurements of the difference of phase are nevertheless important, since, from its value, a good approximation may be made to the energy lost in Foucault currents and hysteresis. These losses are very difficult to measure when alternating currents are employed; for although Prof. Ewing's researches enable us to calculate with accuracy hysteresis losses occurring with slowly varying currents, it is quite uncertain how far these results are applicable to alternating currents of frequencies such as are used in practice.

A lengthy and somewhat acrimonious correspondence is being carried on in the Brighton local press with regard to the present position and future policy of the Brighton Electric Light Company. It is now nearly nine years ago that the historical firm of Messrs. Hammond and Co. commenced to run a small arc light installation in that town; and it is this "pioneer" installation, considerably enlarged and modified of course, which is now in danger of extinction. In 1881 there was no Electric Lighting Act, and the Brighton Company ran its wires pretty well as it pleased. In 1883 or thereabouts the Corporation obtained a Provisional Order, but finding subsequently that the electric lighting business was not the El Dorado predicted, prudently refrained from making use of its powers. Last year, however, stirred into action by the Board of Trade, who said an Order would be granted to the Brighton Company unless the Corporation commenced operations, active steps were taken by the municipality, the outcome of which was the electric lighting scheme, which is to be formally inaugurated on Tuesday next by the Mayor and Corporation.

But apparently the Brighton Company does not intend to fall in with this little arrangement. Trammelled neither by Provisional Order nor Licence, it can, provided the Brighton Corporation does not possess a special Act, giving it power to deal with overhead wires, by securing contracts for lengthened terms with its present subscribers, and by making the utmost use of the flexible qualities of the transformer system, prove a formidable competitor with the Municipality. The Company will have, of course, to comply with the Board of Trade regulations with regard to overhead wires, and to run the risk of being refused way-leaves, and harassed by indictments, injunctions, and other legal weapons. A compromise is, however, proposed by the Company. If the Corporation will support the Company in obtaining an Order for the area not as yet included in the Municipal scheme, the Company will abandon all idea of competition within the Municipality's district. Such a concession on the part of the Corporation would undoubtedly be generous; but the past history and struggles of the Company entitle it, in our opinion, to more generous treatment than has hitherto been accorded it by the Brighton Corporation. However, be the outcome what it may, the situation at Brighton is decidedly instructive; from it electric supply companies can learn what treatment to expect at the hands of Local

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Authorities; and it may also afford a test of the possibility of an unlicensed Company competing successfully with an overbearing Municipality.

THE unfortunate result of the Edinburgh Exhibition should be a warning to those who, from public spirited motives, start a guarantee fund, and to those who for less praiseworthy reasons like to add their names to it. That it will be a warning to professional Exhibition promoters is not to be expected. A dinner and a cheque for somebody is always ready before the fabric is dismantled. The Exhibition was, to begin with, professedly electrical. The two representative bodies of the electrical trades and profession, however, gave it no encouragement whatever, and one strongly expressed the feeling that no such Exhibition was necessary. No promises of a selection of the best things from the Paris Exhibition, or the transference of the complete Edison exhibit could warm unwilling manufacturers into enthusiasm. But a few north-country firms, who have had no opportunity of exhibiting on an extensive scale before, have probably learned the lesson that their London friends have already been taught, as to the commercial value of an exhibit and a medal.

Dewsbury.—The Town Council have decided to apply for an electric lighting order.

Kidderminster.—The Town Council have decided to apply for an electric lighting order.

Gloucester.—At the last meeting of the City Council it was decided to apply for a Provisional Order.

Weston-super-Mare.—The Improvement Commissioners have decided to apply for an electric lighting order.

Croydon.—The Croydon County Council have decided to apply for an electric lighting order.

Brighton.—The Mayor will lay the foundation stone of the Corporation Generating Station on Tuesday next.

Hanley.—The Town Council at its last meeting decided to obtain an electric lighting order.

Personal.—The degree of Doctor of Science was yesterday conferred on Mr. J. T. Bottomley, F.R.S., by the Royal University of Ireland.

Electric Light Signalling.—Experiments have been made during the past week in electric light signalling from Hindhead to Aldershot, a distance of 12 miles.

Hamburg.—The municipal central station, which already supplies 7,500 lights, is about to extend the length of its mains by 2,000 metres, and it will then supply current to 2,000 more lamps.

Royal College of Science, London.—The Queen has been pleased to direct that the Government Institution now known as the Normal School of Science and Royal School of Mines shall in future be called the Royal College of Science, London.

The Halifax-Bermudas Cable.—The Halifax and Bermudas Cable Company's cable has been duly tested by the Government, who paid the first quarterly subsidy last week, according to the terms of their agreement with the Company.

National Telephone Company Appointment.—Mr. John D. Miller, district manager of the National Telephone Company, Dundee, has been appointed the Company's general manager for the division of Scotland north of the Forth.

Electric Light in Coal Pits.—The Fife Coal Company have arranged for the introduction of the electric light into their pits at Leven, in place of each miner carrying his own lamp. It is proposed to light the roads, the lamps to be 15 yards apart.

Loss by Hysteresis: a Correction.—In Mr. G. L. F. Philips's letter on "Loss by Hysteresis," which appeared on p. 721 of our last issue, the words "magnetic irresistance," in the last paragraph, should read "*magnetic air resistance.*"

Electric Lighting of Aldershot Camp.—A proposal, it is stated, has been made, and is now under consideration by the military authorities, to carry out the lighting of the whole of Aldershot camp by means of electricity, and it is expected that a preliminary trial will shortly be made.

Preston.—The Streets and Buildings Committee of the Corporation have approved of a temporary installation for the lighting of Fishergate, the principal thoroughfare of the town, by electricity. Current is to be supplied by the National Electric Supply Company.

Church Lighting.—St. Stephen's, Westminster, which was closed during August for repairs, was reopened last week. This church, which was erected in 1850 at the expense of the Baroness Burdett-Coutts, has undergone considerable improvement, the principal innovation consisting in the substitution of the electric light for gas.

Barmen.—The municipal installation is to be increased next year so as to provide for the lighting of Oberbarmen and Unterbarmen. For this purpose four accumulator stations, with the necessary engine and boiler plant, dynamos, cables, distributing boxes, &c., will be provided by Messrs. Schuckert and Co., at a cost of £70,000.

The Lighting of the City.—The Streets Committee of the Commissioners of Sewers will meet on Friday, November 28th, at the Guildhall, and open tenders for lighting the western district of the City by electricity. The conditions are similar to those in respect of the eastern and central districts. Tenders may be sent in up to two o'clock on the day mentioned.

Heckmondwike Local Board.—At a meeting of this Board, held on Monday, a long discussion took place respecting the electric lighting project. The Chairman moved that steps be at once taken for making application to the Board of Trade for a Provisional Order. The motion was carried by the casting vote of the Chairman.

Grosvenor Gallery.—The supply from the Grosvenor Gallery will be discontinued after next week, and the machinery will be removed to Deptford. The pressure on the Deptford mains will probably be raised to 10,000 volts in order to avoid overloading the dynamos with current. The armatures, though designed for 100 amperes, are found to carry 160 without overheating.

Telegraphists' Strike in America.—A *Times* telegram states that all the Western Union Company's operators at St. Paul, Minnesota, struck on Monday night because six of their number belonging to the new secret order of telegraph operators were discharged. There have been similar dismissals in other cities. The Omaha operators are out also. The business of the Western Union Company is stated to be partially crippled.

The Iron and Steel Institute at the Edison Laboratory.—On Friday, October 2nd, the members of the Iron and Steel Institute, now in America, paid a visit to the Edison Laboratory. About 200 visitors were expected, but no fewer than 500 arrived. Before leaving all gathered together again in the library, where Sir John Kitson, president of the Institute, thanked Mr. Edison, in its name, for the pleasure he had given them all.

Telegraphy in the Transvaal.—There are now 31 telegraph offices open in the Transvaal, and in the quarter ending March this year 149,377 messages were despatched, while 141,229 were received. In these totals Johannesburg figured with 76,388 and 71,373 telegrams respectively. The amount received for the telegrams despatched from the Transvaal during the three months ending March 31st this year was £12,417. 15s. 2d.

Moss Side Local Board.—At the last meeting of this Board a letter from the Manchester House-to-House Electricity Company, under date October 13, was read, asking the Clerk to bring the matter of street lighting before the Board with a view to opening negotiations for the substitution of the electric light, either arc or incandescent, for gas. It was decided that the plans asked for should be supplied to the Company, and every facility afforded it for lighting the township with the electric light.

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Owens College, Manchester.—A prize of £10 has been offered by Mr. William Mather, M.P., for the best essay on some subject connected with the technical applications of electricity, the competition being open to students working in the Physical Laboratory of the Owens College during the day or evening. The award is to be given at the end of the present session, and Dr. Edward Hopkinson has offered a similar prize to be awarded next session. The subject for the present session is "Recent Progress in the Science of Magnetism."

Electrical Engineering Corporation.—Mr. Carl von Buch, of Messrs. Foote and Von Buch, electrical engineers, 11, Queen Victoria-street, E.C., has joined the Board of the Electrical Engineering Corporation. This corporation has for the last nine months been making considerable extensions at their works at West Drayton and these are now complete. In the course of a week their new machinery will be put to work, and among the new machine tools there will be some of the largest employed in the electrical industry.

Telephone Wires in Sheffield.—The Highway Committee of the Sheffield Town Council have declined to grant permission to the National Telephone Company to erect poles in Ecclesall-road, but have granted an application of the Company for permission to lay underground wires in the centre of the town. It was also decided that in future the Committee should not approve the further erection of poles, but, so far as practicable, give every facility for placing the wire cables under the surface at the uniform rate of 20s. per mile per annum.

"The Iron and Coal Trades Review."—The potential capabilities of electricity as applied to mining and kindred operations have evidently impressed our mining contemporary, which in its last issue brought out a twenty-page special supplement, a large proportion of which was devoted to matters electrical. Amongst the electrical articles was one on "Electric Light and Power in Mines," and another entitled "A Practical Guide to the Electric Lighting of Mines and Collieries," specially written for the supplement.

The Electric Light and the Defence of the Thames.—The Commander-in-Chief has sanctioned the carrying out of important experiments in connection with the electric light and its efficacy in protecting the entrance to the Thames. Major-General Goodenough, commanding the Thames District, is in charge of the operations, which will be carried out at various points below Gravesend. Torpedo boats have been requisitioned to furnish a supposed enemy, and the operations are to be made with a view to determine the best positions at which electric search lights could be placed.

Electric Welding Progress.—A welding machine will soon be turned out at the Lynn works of the Thomson-Houston Company, intended for welding sections of 6in. extra heavy pipe together endwise. The current developed in this machine is expected to reach 70,000 amperes, though its normal work will demand somewhat less than this. Great attention has also lately been given to the development of machinery for chain work, and a small apparatus has been constructed which takes wire from a reel and turns out lengths of chain with electrically welded links, the operation being automatic throughout.

Bath.—At the last meeting of the Surveying Committee the bills presented included £523. 19s. 4d., being Mr. Massingham's quarterly bill for the electric light. Mr. Sturges said he had gathered from the police report book that there had only been two failures of the electric light since March, while, on the other hand, there had been 28 cases of gas failures in the same period. Mr. Massingham had done his best to make the light a success, and to be over particular in the first quarter would perhaps be more nice than wise. In future, however, he must be given to understand that all failures must be paid for. The bill was passed, and referred to the Finance Committee.

Richmond.—At the last meeting of the Vestry the report of the Electric Lighting Committee was read. It stated that the draft contract submitted to them by Messrs. Latimer Clark, Muirhead, and Co., had been fully considered by the Committee, with the assistance of Mr. J. N. Shoolbred. A letter, dated October 7th, had also been received from the Board of Trade, requesting to know whether any steps have or are proposed to be taken to give effect to the Provisional Order granted to the Vestry in 1883. The Committee expressed a hope that the new Town Council would proceed with the matter from the point now arrived at by the Committee.

Sunderland.—At the last meeting of the Town Council the Highway Committee recommended that all the necessary notices should be given, and steps taken in order to obtain an electric lighting Order. Mr. J. Harrison, in moving the adoption of the report, said that when they got the order, they would light up the centre of the town and both sides of the river. If they subsequently found that it was beyond the practical ability of the Council to control the works for the supply of electricity, they were at liberty to dispose of their powers to a company. After some discussion, the report was put and carried.

Destruction of Electric Light Wires by Firemen.—Owing to the heavy losses suffered by American electrical companies, whose wires are hastily and clumsily cut by firemen whenever a fire occurs in a city, the electrical companies are thinking of adopting some means of preventing this destruction of their property. At the recent convention of fire department chiefs in Detroit, it was suggested that the electrical companies should keep a corps of men, with waggons equipped with appliances for cutting wires, who should go to fires and do all the handling of wires necessary. Another idea is, for the electrical companies to keep a man at each engine-house to go with the engine to fires and direct the wire cutting operations.

Cable Extensions.—The French Government has decided to sanction the laying of a new cable between France and Denmark, in order to obviate the frequent interruptions of communication at present occurring between the two countries, and to establish telegraphic communication between Marseilles and Tunis, and Marseilles and Oran. In pursuance of an Imperial order, the Turkish postal authorities are about to connect the island of Crete with Benghazi by a submarine cable. Telegraphic communication is also to be established between Benghazi and Tripoli. The Telegraph Construction and Maintenance Company are about to make and lay, for the Eastern Telegraph Company, a quadruplicate cable from Suez to Perim and Aden.

The City and South London Railway.—Two summonses were heard against the City and South London Railway Company at Lambeth this week for building stations at the corner of New-street, Kennington-park-road, and Harleyford-road beyond the line of frontage, and without the consent in writing of the London County Council. These stations, it was contended, had been built upon the old forecourts of houses and brought out right to the garden rail, and beyond the original and proper line of frontage. The County Council considered the Company had built such stations without sanction, and contrary to the Building Act. The defence was that the Company had powers under their own Act of Parliament to do as they had done. After lengthy arguments on either side the further hearing of the matter was adjourned.

Presentation to Mr. A. R. Bennett.—On October 23rd a deputation, consisting of about 20 of the National Telephone Company's *employés* in Scotland, comprising all the principal district managers and engineers, waited on Mr. Bennett and presented an illuminated address recapitulating his services to the Company during the eight years of his administration as General Manager of their affairs in Scotland, and expressing regret at his resignation and good wishes for the future. The address was accompanied by a set of Sir William Thomson's electrical testing apparatus, manufactured by the India-Rubber, Gutta-Percha, and Telegraph Works, of Silvertown. The presentation was acknowledged by Mr. Bennett in suitable terms, and he was afterwards entertained to luncheon at the Windsor Hotel.

Loughborough.—At the last meeting of the General Purposes Committee of the Town Council, the application of the Loughborough Electricity Supply Company for the consent of the local authority to their Provisional Order was considered. It was unanimously decided that the committee should report to the Council that they are of opinion there is not at present such a demand for the electric light as would justify either the Corporation or the Brush Electrical Engineering Company in obtaining electric lighting powers, and to recommend the Council to request the

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Company to withdraw their present application on condition that the Corporation will themselves apply for a Provisional Order next year, or consent to the grant of such order to the Brush Company on terms and conditions to be defined before October 1, 1891; the Corporation undertaking to refuse their consent to the grant of a Provisional Order or licence to any other company pending the negotiations with the Brush Company.

The Paris Telephone System.—On and after Monday next any subscriber to a telephone, and any person entering the telephone offices, will be allowed to speak to any of these offices a message to be transcribed and conveyed to a person living in the district. The charge will be 50 centimes for five minutes, and the message will be limited to 100 words—The work of altering and enlarging some of the main sewers, with a view of facilitating the connecting of the new central telephone exchange in the Rue Gutenberg with the various subsidiary exchanges, is now being vigorously pushed on. In some instances the sewers will be entirely transformed. Thus in the Rue Faubourg-Montmartre the tunnels will be about 13ft. broad by 10½ft. high, with a cunette 4ft. deep in the middle. On either side of this cunette there will be a platform 2ft. wide, one of which will be used by the Municipal Sewers Department, while the other will be given over to the telephone service. The roof of the tunnel will rest on cast-iron pillars, and on brackets fixed to these will be run the Patterson 50-wire telephone cables. These Patterson cables, which are of American make, are manufactured as follows:—The cabled wires, each of which is first covered with ordinary cotton, are placed inside a lead tube, and paraffin is then forced into the interstices between the conductors and the lead covering. The cost of this work will be shared between the Municipality and the Postal Telegraph Department.

Bradford.—In their annual report to the Town Council the Gas and Electricity Supply Committee state that since the opening of the electricity works on September 20, 1889, the supply of electricity has been continued regularly on all week-days. To meet the convenience of many of the consumers the supply, since the 13th of May last, has been commenced at 10 a.m. and continued to 11 p.m. on the first five days of the week, and to 11:30 p.m. on Saturdays. Owing to the rapid increase in the demand for a supply of electricity, the whole of the plant, including the spare machinery, was in use by the end of December last. To meet the increasing demand the committee ordered from Messrs. Siemens' Brothers and Co. an additional Willans' engine of 300 indicated horse-power, coupled direct to a Siemens' dynamo capable of developing 240 electrical horse-power, together with the necessary feeding mains and instruments. A set of storage cells which has been ordered from Messrs. Crompton, Howell and Co., is now being fixed at the works for the purpose of supplying current at any time when the demand is not sufficient to keep the engines fully employed. These cells will have a capacity of 1,000 ampere hours. Between two and three miles of distributing mains have been laid during the past year. The plant, which will be available for the ensuing winter, will consist of three mild steel Lancashire boilers of 180 indicated horse-power each, and four steam engines of the inverted vertical type, three of 150 indicated horse-power each, and one of 300 indicated horse-power, working at 120lb. steam pressure. Three of these engines are by Messrs. Willans and Robinson, and the fourth is by Messrs. Marshall, Sons, and Co. Each engine is coupled direct to a Siemens' dynamo, three being capable of developing 120 electrical horse-power each, and the fourth 240 electrical horse-power.

Technological Examinations.—It is now just twelve years since the City and Guilds of London Institute started their system of technological examinations. The 202 candidates of 1879 multiplied themselves, two years later, into 1,563, and this again was more than doubled in 1884, when 3,365 papers were worked. The rapid increase continued till 1888, when the number 6,166 was reached, and for the last two years the numbers have gone up, though less rapidly, 6,781 being the total for the present year. That the percentage of failures is greater than last year may presumably be attributed to a raising of the standard. In the first years of the examinations the percentage was about 40; now it has reached 48·2. Out of the 54 subjects included in the programme, examinations were held in 49. The most popular subject was mechanical engineering, for which 972 candidates entered, but of these no less than 701, or 72 per cent., failed. Cotton-spinning comes next, with 949 candidates, of whom 525 passed. Carpentry and joinery, as might be expected, had a large number—707. In plumbing 569 entered for examination, though less than half—233, or 41 per cent.—passed. Electric lighting attracted 256. The practical tests which it has been found possible to introduce into some of the subjects form an important feature. The difficulty of carrying out such tests effectively is obvious when it is remembered that the examinations are carried out simultaneously in 176 towns scattered all over the Kingdom, and under the supervision of committees not professing any knowledge of the subjects of examination. However, to a certain extent the difficulty has been surmounted. Of the candidates examined, but 16·6 per cent. are not taught in the special classes established by the Institute. Of these classes there are now 483, attended by no less than 12,022 students. Just half these students were examined last year, and half again of those examined passed. There were 32 Colonial candidates examined at Sydney, simultaneously with those in England; 19 of them passed. Last year 29 were examined, of whom 23 passed. From some other Papers, presented with the annual report, from which the figures are taken, it appears that there were, up to the 4th inst., 154 students at the central institution of the Guilds Institute at South Kensington. The numbers at the Finsbury Technical Schools are considerably higher. There 1,152 students attended during the last completed year, 1889-90.

Edinburgh Exhibition.—Mr. Lee Bapty, general manager of the Exhibition, was entertained at dinner last week by the exhibitors in the Royal dining-rooms, and presented with a cheque for £500. —The Edinburgh correspondent of *The Times* states that it was officially announced on Monday that the letters of the guarantee fund of the Edinburgh International Exhibition had been hypothecated to the British Linen Company Bank in security of advances, and that this was accepted as a confirmation of the disquieting rumours that had been flying about for some time as to the large deficit that the balance-sheet of the Exhibition was likely to disclose.—In the first division of the Court of Session, on Tuesday, Messrs. Drysdale and Gilmour, contractors, presented a petition for the judicial winding-up of the Edinburgh International Exhibition Association. The petitioners, who erected the Exhibition buildings, stated that there was still a balance of £9,000 due to them, which the Association, although called upon, have failed to pay. They stated further that the amount of the guarantee fund of the Exhibition was £26,000, and the only assets were this fund and the Exhibition buildings, which at the close of the Exhibition on Saturday must be broken up and sold. On the other hand, there were debts amounting to £43,961, including petitioners' debt and £20,000 advanced by the bank. The petitioners stated that the Exhibition would result in a large deficiency and heavy loss to the creditors; and they asked the Court to appoint a judicial liquidator, in order to prevent the bank and other creditors obtaining a preference. The Court adjourned the consideration of the petition.—On Wednesday the petition came before the Second Division of the Court. After some discussion Lord Young, in giving judgment upon the application, said he thought that, without deciding anything about the propriety of the merits of this application for the judicial winding up, they should grant the usual formal order for intimation and service upon the respondents. Their lordships concurred. Answers were ordered to be lodged to the petition within eight days.—On the same day Lord Stormonth Darling heard counsel in the Bill Chamber of the Court of Session in connection with a petition by Gilroy and Company, contractors, against the Edinburgh International Exhibition for intimation and service of the petition and interim interdict against that day's drawing at the Exhibition being paid the British Linen Bank. After a discussion interim interdict was granted on caution being found, answers to be lodged in 24 hours.

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MAGNETISM IN IRON AND OTHER METALS.*—XXXIV.

BY PROF. J. A. EWING, F.R.S.

(*Continued from page 671.*)

§ 122. **Effects of Longitudinal Push on the Susceptibility and Retentiveness of Nickel.**—The reduction of susceptibility and retentiveness in nickel by longitudinal stress is associated with an equally striking augmentation of susceptibility and retentiveness by longitudinal compressive stress. Fig. 97 shows an arrangement by which nickel rods have been tested,† under compression, within a yoke of wrought iron, by means of

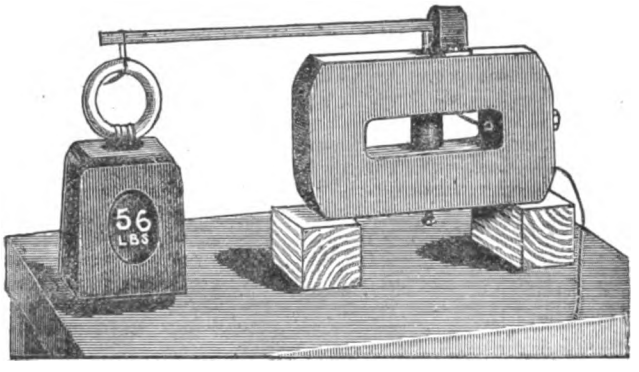

FIG. 97.
Arrangement for testing magnetisation of metals under compression.

the method described in § 58, the total magnetisation being determined ballistically by reversing **H**, and the residual magnetisation by deducting the ballistic effect got by removing **H** from half the ballistic effect got by reversing **H**. The influence of a number of loads was examined, ranging up to 19·8 kilos. per sq. mm. Every addition of load produced a decided increase of susceptibility, and caused an increasing fraction of the whole magnetism to be retained on the withdrawal of the magnetising force, until finally, under the heaviest load, the

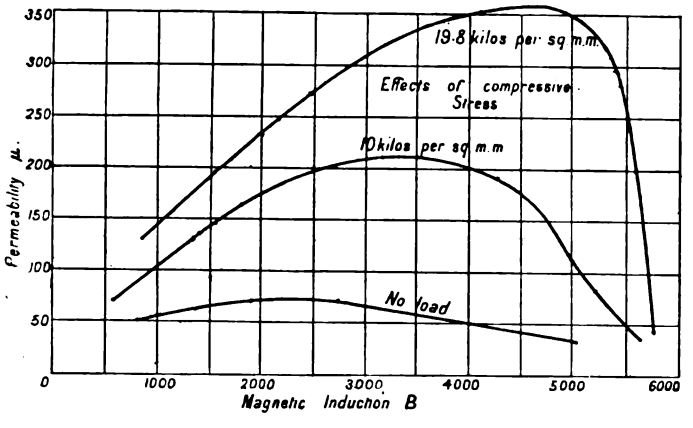

FIG. 100.
Permeability of Nickel in the hard state.

magnetisation curve rose with remarkable steepness, and the maximum proportion of residual to total induced magnetism reached the astonishingly great value of 0·96. In this group of experiments the nickel rod was in a hard (unannealed) state.

The results of the observation are shown in Figs. 98 and 99.

Fig. 98 gives the induced magnetism **I** in terms of **H**, under each amount of longitudinal compressive stress; and Fig. 99 gives the residual magnetism, which was observed in the usual way by withdrawing **H** at a number of stages during the taking of each magnetisation curve. Especially to be noted is the sharpness with which the curve of induced magnetism, under the heaviest stresses, bends over when **H** is about 20. The approach towards saturation is extremely rapid, and the change from a highly susceptible state to an insusceptible, because nearly saturated, state is remarkably abrupt.

Fig. 100 shows the result of the same experiment in a different way: the permeability μ is plotted there in relation to **B** for three conditions of stress which are specified on the curves.

Fig. 101 records a corresponding set of observations made on a nickel rod in the annealed state, under compressive stresses ranging up to 6 8 kilos. per square mm. The curves of μ and **B** which relate to this experiment have already been shown in Fig. 41, § 75.

§ 123. **Effects of Cyclic Variation of Longitudinal Stress on the Magnetism of Nickel.**—As might be anticipated from the curves that have been given above, a magnetised nickel wire subjected to cyclic variations of pull by loading and unloading it with suspended weights suffers much reduction of its magnetism when the weights are put on, and much increase of its magnetism when the weights are taken off. This happens whether the magnetism be induced or residual.

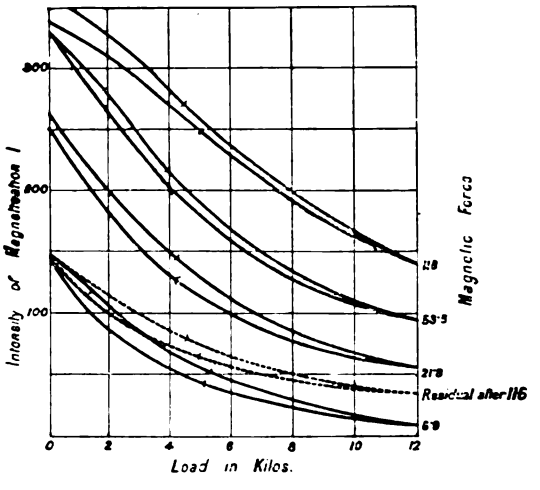

FIG. 102.
Effects of Loading and Unloading Nickel Wire in Various Constant Fields.

In Fig. 102 a number of curves are drawn to show the observed effect (upon **I**) of applying and removed loads while the magnetising force specified in the margin of the figure remained continuously in action. The dotted curves in the same figure show how the residual magnetism which was left after the action of the strongest force (**H** 116 C.-G.-S.) was affected by loading and unloading. In this experiment each kilogramme of load corresponds to a stress of 2·75 kilos per square mm. When these curves are compared with corresponding curves for iron, which will be given later, it will be seen that there is comparatively little hysteresis of magnetism with respect to stress in these.

There is, however, some hysteresis; the curve for the process of loading invariably lies above the curve for the process of unloading, even when the cyclic variations of stress are repeated often enough to make the magnetic changes become strictly cyclic. With hardened nickel wire, tested under a wider range of stresses, there is even less hysteresis than here.

(*To be continued.*)

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† *Phil. Trans.*, 1888, A, p. 333.

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MAGNETISM IN IRON AND OTHER METALS.

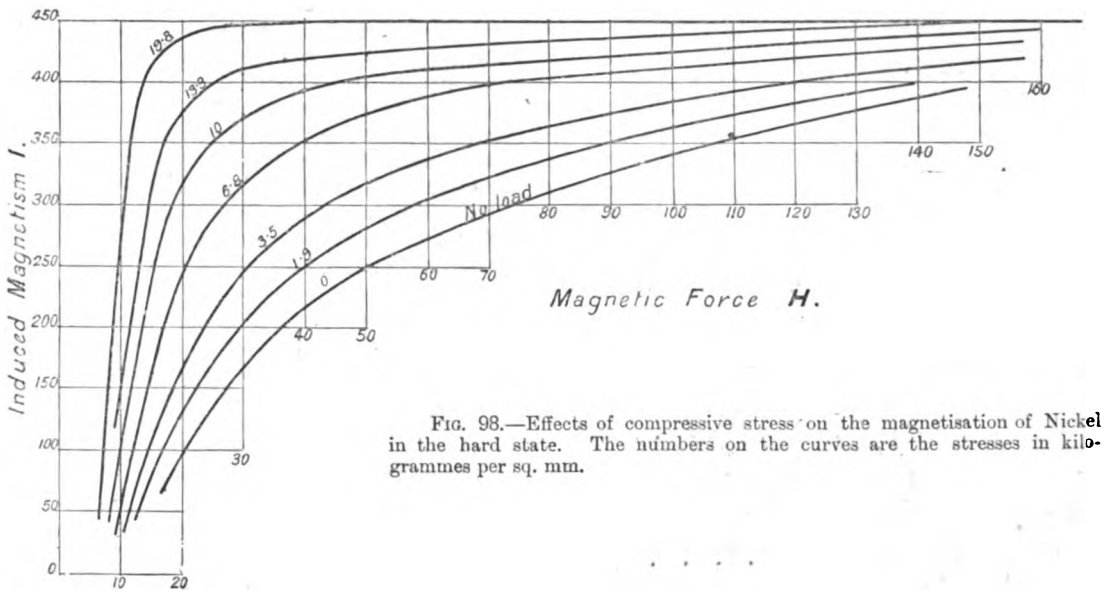

FIG. 98.—Effects of compressive stress on the magnetisation of Nickel in the hard state. The numbers on the curves are the stresses in kilogrammes per sq. mm.

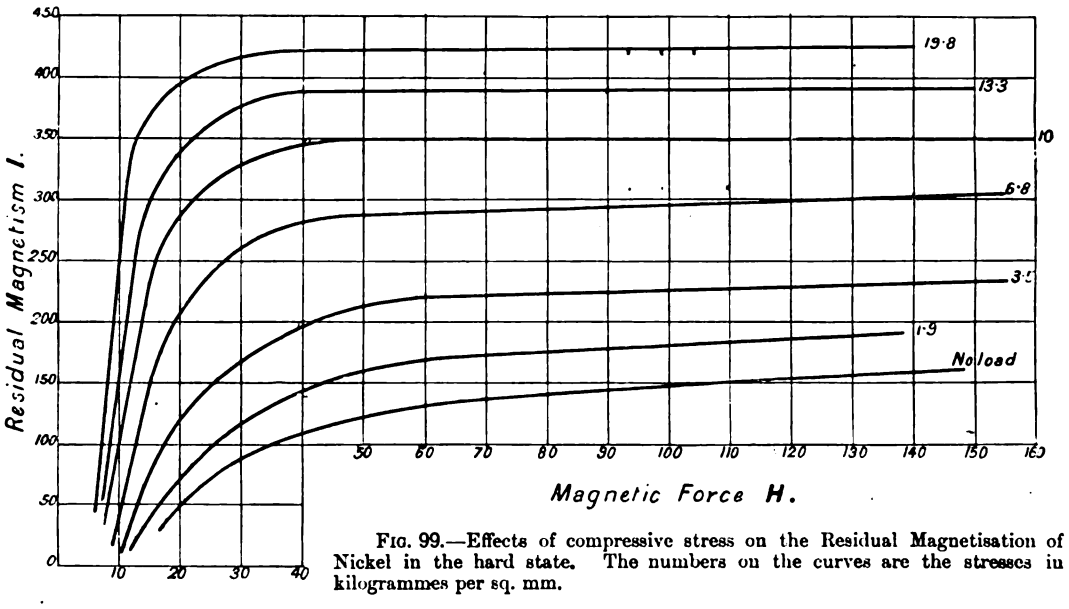

FIG. 99.—Effects of compressive stress on the Residual Magnetisation of Nickel in the hard state. The numbers on the curves are the stresses in kilogrammes per sq. mm.

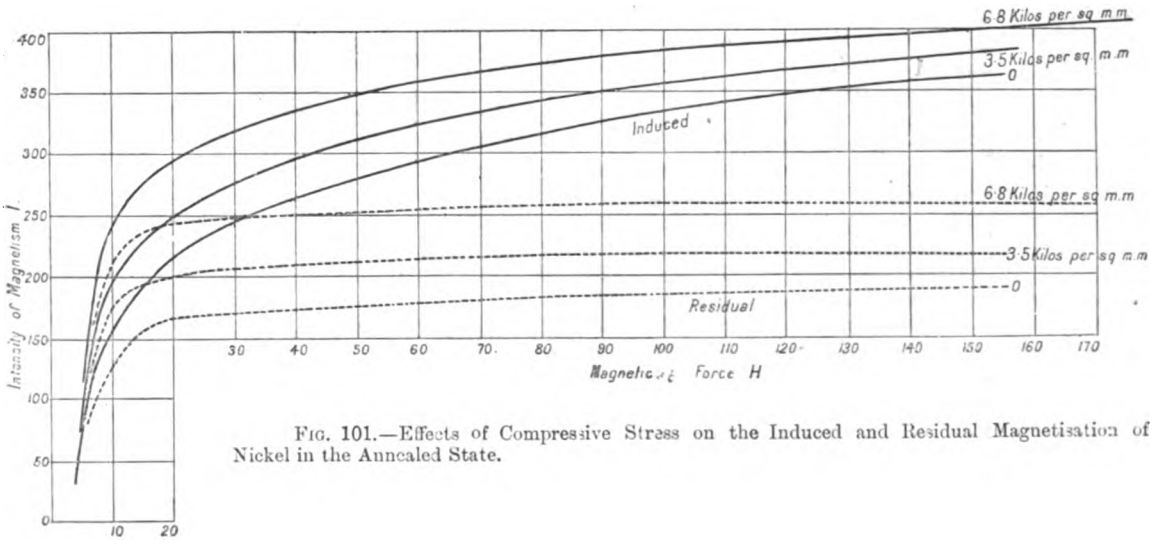

FIG. 101.—Effects of Compressive Stress on the Induced and Residual Magnetisation of Nickel in the Annealed State.

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ON THE ELECTRO-DYNAMICS OF STATIONARY BODIES.*

BY H. HERTZ.

(Concluded from page 637.)

PART B.

EXPLANATION OF THE PHENOMENA BY MEANS OF THE FUNDAMENTAL EQUATIONS.

Steady Flux of Magnetic Force.—If the values of u, v, and w are known, we may most readily obtain the components of the magnetic force by making use of an auxiliary quantity called vector potential, whose components U, V, W are given by the equations

$$U = \int \frac{u}{r} d\tau, \quad V = \int \frac{v}{r} d\tau, \quad W = \int \frac{w}{r} d\tau \quad . . (37)$$

These integrals are supposed to be extended throughout all space. From (32) it follows that

$$\frac{dU}{dx} + \frac{dV}{dy} + \frac{dW}{dz} = 0 \quad . . . . (38)$$

and, by making use of this equation, it can be shown that (30) will be satisfied if

$$\left.\begin{aligned} L &= A\left(\frac{dV}{dz} - \frac{dW}{dy}\right) \\ M &= A\left(\frac{dW}{dx} - \frac{dU}{dz}\right) \\ N &= A\left(\frac{dU}{dy} - \frac{dV}{dx}\right) \end{aligned}\right\} \quad . . . (39)$$

where

$$\frac{dL}{dx} + \frac{dM}{dy} + \frac{dN}{dz} = 0 \quad . . . . (40)$$

As an example, let us consider the force exerted by an element of current at a distant point $x'\ y'\ z'$. If the strength of the current is i, and the element ds has components dx, dy, dz, we may in (37) substitute $i\,dx = u\,d\tau$, $i\,dy = v\,d\tau$, $i\,dz = w\,d\tau$; and, if we regard the magnetic force exerted by the current as the sum of the forces exerted by each element separately, we obtain for the element in question, when the point $x'\ y'\ z'$ lies in the plane $x'\ y'$

$$L = 0 \qquad M = 0,$$

$$N = A\,i\,dx\frac{d\frac{1}{r}}{dy'} = -\frac{A\,i\,dx}{r^2}\frac{y'}{r}$$

which expresses Ampère's rule, and the law of Biot and Savart.

Reference to equations (30) will show that whenever u, v, and w vanish, as they do outside a conductor, the values of L, M, N can be obtained by differentiating a potential function, ψ, with regard to x, y, z respectively, and afterwards changing the sign. If the forces are the result of a single closed current, i, the potential ψ takes the form

$$\psi = -Ai\int \frac{d\frac{1}{r}}{dn}\,dw + \text{a constant} \quad . . (41)$$

Where dw is an element of a surface bounded by the current contour; n is a length drawn in the direction of the normal; and the integration is extended all over the surface so bounded. That side of the surface is to be considered positive from which the current appears to circulate in a clockwise direction. The derivatives of ψ are finite and continuous everywhere outside the currents; and, if at the surface, w, the value of ψ becomes discontinuous, we may regard the constant as not absolutely fixed, and by increasing its value by $4\pi A\,i$ each time the path of integration crosses the surface, the function ψ becomes quite continuous from point to point, although it is many-valued.

The integral expression for ψ is susceptible of several interpretations. In the first place, we may consider it as the potential due to a double magnetic layer, and this view leads naturally to Ampère's theory of magnetism.

On the other hand, we may consider, with Gauss, that the value of ψ represents the spherical angle subtended, at the point in question, by the current contour. This method of regarding the matter enables us to see the exactitude of the statement that the value of the integral at any point is equal to the number of the lines of force which start from a unit pole placed at the point, and are enclosed by the current contour.

It is, moreover, always true that the difference in the value of ψ at two points is equal to the product of $A\,i$, and the number of lines of force which cut the electric circuit when a unit magnetic pole is moved in any way whatever from the first point to the second.

It is this last interpretation which it is most useful for us to consider. It follows that the mechanical work necessary to bring up a magnetic pole or other invariable magnetic system to a circuit traversed by a constant current i, is measured by the product of $A\,i$ and the number of lines of force due to the magnetic system, which are cut, during the movement, by the electric circuit. Similarly, the mechanical work required to displace a circuit through which a constant current i is flowing, is measured by the product of $A\,i$ and the number of lines cut by the current during the displacement.

Finally, the mechanical work required to displace two electric circuits traversed by constant currents is equal, either to the product of the constant A, the strength of the first current, and the number of lines due to the second current and cut by the first during the displacement, or to the product of the constant A, the strength of the second current, and the number of lines due to the first current and cut by the second as the result of the movement The two expressions lead to the same result; for, if we distinguish by dashes quantities referring to the second current, we have for the first expression

$$A\,i\,i'[L'\cos(n,x) + M'\cos(n,y) + N'\cos(n,z)]\,dw,$$

and this, by suitable transformations. can be shown to be equivalent to

$$-A^2\,i\,i'\iint \frac{\cos\epsilon}{r}\,ds\,ds',$$

where ds, ds' are elements of the two electric circuits, at a distance r from each other, and inclined at an angle ϵ. Since this expression is symmetrical for the two circuits, the foregoing statement is verified. The product of $A^2\,i\,i'$ and the variation of Neumann's potential represents the work needed to produce any displacement, and its rate of variation thus determines the mechanical force exerted between the two circuits when at rest. The expression for the force thus obtained contains all that we know with certainty regarding the mechanical forces exerted by currents.

Dynamical Phenomena.

Up to the present, among the great variety of possible forms of the variable state, only a very small group of phenomena has been observed.

Induction in Closed Circuits.—The electric forces arising in a variable magnetic field are in general very feeble, because they contain a very small factor, the constant A [*see* (10) and (11)]; and the perception of these forces is only possible when they produce currents in closed circuits, or when their actions accumulate in linear circuits which are well nigh closed.

The actions which can be measured in researches are always the result of the integral action of the electric force taken around a closed circuit, and represented by the expression

$$\int (X\,dx + Y\,dy + Z\,dz).$$

By transforming this line integral into a surface integral, and by making use of (10), it is possible to show that this expression is equivalent to

$$A\frac{d}{dt}\int [L\cos(n,x) + M\cos(n,y) + N\cos(n,z)]\,dw,$$

or to the product of A, and the rate at which lines of force cut the circuit.

In particular, if the induction is produced by a variable closed current, and if there are no magnetisable bodies in

* An abstract of a paper published in the "Nachrichten von der Königlichen Gesellschaft, der Wissenschaften," for March, 1890; and reprinted in *La Lumière Électrique*, July, 1890.

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the neighbourhood, the induced electromotive force is equal to the product of A^2, the time rate of change of the inducing current, and the potential of Neumann with reference to the two circuits.

These two principles, of which the former is the more general, embrace all induction phenomena which have been observed in stationary conductors.

The induction which takes place in moving conductors is, strictly speaking, not included in the field covered by the present Paper. We may, however, for linear conductors, connect this case with those already studied, by making use of the following principle. The electromotive force induced in a circuit will have the same value, whether the variation of the surrounding magnetic field is produced by the movement of ponderable bodies, or by purely electro-magnetic phenomena, provided only that the variations is the same in the two cases.

It follows that the electromotive force generated in a moving circuit is equal to the product of A, and the rate at which lines of force are cut by the circuit. The product of this electromotive force and the strength of the current in the moving conductor represents the rate at which chemical or thermal energy is generated by the induction.

This energy can also be shown to be equal to the mechanical work done by the exterior moving forces during the motion. Thus if a circuit conveying a constant current is moved in the neighbourhood of a fixed magnet, the work required to produce the movement is the exact equivalent of the thermal or chemical energy generated in the circuit, provided the magnetic energy of the system does not change. If, on the other hand, two circuits conveying constant currents are moved with reference to each other, the thermal or chemical energy appearing in one of the circuits compensates the mechanical energy absorbed by the motion, while the energy appearing in the other circuit compensates exactly the loss of the electro-magnetic energy of the system. In other words, the total energy produced is the exact equivalent of the energy destroyed.

Unclosed Circuits.—The extent of this subject is apparently the largest of all, as it embraces all those problems which cannot be considered as particular cases of the other subjects. However, having regard to the experiments actually possible, this subject is the poorest of all.

The oscillations which are produced in unclosed induction coils, or by the discharge of Leyden jars, can be studied with sufficient approximation by means of the principles established in the preceding sections. Properly speaking, electrical waves and the oscillations occurring with short waves belong to this chapter. It must be observed that a division of the electric force into an electrostatic force, and an electrodynamic one in these general problems, has no clear or precise physical significance, nor does it yield any valuable mathematical advantage. This method of study we therefore abandon in favour of others which are more convenient and fruitful.

Movement of Light in Isotropic Bodies.—We consider the domain of optics to embrace all electro-dynamic movements which are periodic with regard to time, and which are so rapid that at least a thousand million periods occur in a single second.

Let us restrict ourselves to bad conductors, which are homogeneous and isotropic. We then obtain from equations (1) and (2) by elimination

$$A^2 \epsilon \mu \frac{d^2 \theta}{dt^2} = \Delta \theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (42)$$

where Δ stands for the operator $\frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2}$, and where we may substitute for θ either L, M, N, X, Y, or Z.

We also have from (3)

$$\frac{dL}{dx} + \frac{dM}{dy} + \frac{dN}{dz} = 0 \quad . \quad . \quad . \quad . \quad . \quad (43)$$

$$\frac{dX}{dx} + \frac{dM}{dy} + \frac{dN}{dz} = 0 \quad . \quad . \quad . \quad . \quad . \quad (44)$$

The solution for θ in (42) is a periodic function, representing a wave whose vibrations are transverse to the direction of propagation. The velocity of propagation is for all possible waves equal to the reciprocal of $A\sqrt{\epsilon\mu}$, and the phenomena of rectilinear propagation, reflection, interference of natural and polarised light, and various types of polarisation can all be explained as a consequence of such wave propagation. On further reference to equations (1) and (2) we see that at each point on a plane wave the directions of the simultaneous electric and magnetic forces are perpendicular to each other.

Suppose that the surface separating the two non-conductors is the plane of $x\,y$. We have in this case, since we are only considering periodic movements—

$$L_1 = L_2 \qquad X_1 = X_2$$
$$M_1 = M_2 \qquad Y_1 = Y_2$$
$$\mu_1 N_1 = \mu_2 N_2 \qquad \epsilon_1 Z_1 = \epsilon_2 Z_2$$

Each of these systems of equations which hold at the surface in conjunction with those which are true within the media yield the laws of reflection, refraction, and of total reflection; that is to say, the fundamental laws of geometrical optics. Each of these systems shows also that the intensities of reflected and refracted waves depends on the plane of polarisation. They yield the same formulæ as Fresnel gave for these relations, and also for the retardation of phase occurring in total reflection.

If to obtain these formulæ we make use of the electric forces (equations (42) and (43) substituting L, M, or N, for θ) we pursue a method analogous to that of Fresnel. If, on the contrary, we make use of the magnetic equations [*see* (42) and (44) substituting X, Y, or Z for θ] we follow a course pursued by Neumann in obtaining Fresnel's formulæ. From our point of view, not only must the two methods yield the same result, but they can be described as being equally correct. It is, however, the electrical properties of bodies which mostly determine their optical behaviour. In the phenomena of reflection actually observed the electrical and magnetic forces have not exactly the same effect since the magnetic constant of nearly all bodies is close to unity, while the electric constant varies enormously for different media.

If the plane of $x\,y$ separates a bad conductor from a perfect conductor, we have

$$W = 0 \qquad X = 0 \qquad Y = 0.$$

These equations, in conjunction with those holding good for the interior of bad conductors, show that reflection is total at the separating surface, whatever the angle of incidence and the azimuth of the plane of polarisation.

It is known that real conductors occupy an intermediate position between bad conductors and perfect ones, and this is why reflection at their surface is a mixture of total reflection, and reflection such as occurs ordinarily at the surface of transparent bodies. As metallic reflection behaves in the same way, we can conclude that it is represented by our equations.

Optics of Crystals.—In the interior of homogeneous, perfectly transparent crystals, we shall make the supposition that the axes of symmetry of the electric energy coincide with the axes of symmetry of the magnetic energy. We shall take these axes as our axes of x, y, z; and, since for crystals the value of ϵ and μ vary with direction, we shall have to substitute μ_1, μ_2, μ_3 for μ in the three equations (1), and ϵ_1, ϵ_2, ϵ_3 for ϵ in equations (2) Solving these new equations, and obtaining the wave-surface for periodic disturbances, we obtain a surface represented by an equation of the sixth degree. This, however, reduces to the well-known surface of Fresnel, if we put $\mu_1 = \mu_2 = \mu_3$, which is very approximately true. Thus all the phenomena of double refraction, and of reflection and interference occurring with crystals, can be explained on ordinary optical methods. With reference to the wave-surface, we can establish the following statements:—The magnetic force is perpendicular to the electric polarisation, and the electric force to the magnetic polarisation. The direction of the two forces is, in general, outside the surface of the wave; but each direction of polarisation is tangential. The direction perpendicular to the two polarisations is consequently normal to the wave; while the direction perpendicular to the two forces is that in which energy is being propagated, and, in optics, this latter direction is called the direction of the luminous ray.

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THE APPLICATION OF ELECTRICITY TO CRANES.

BY H. D. WILKINSON, M.I.E.E.

In the discussion which followed the reading of Mr. Reckenzaun's comprehensive Paper before the Society of Arts some three years back, on the subject of "Electric Tramways," the question of steam *versus* electrically driven trams or street railways came up; and during the course of the discussion one of the speakers denounced the idea that electricity as a motive power would ever supplant steam. "Not in my time, gentlemen, nor in yours," the speaker went on to assure the meeting, would this take place, if, indeed, it was ever likely to do. The Chairman (Mr. Preece) thereupon showed, in a few sentences, the incorrectness of the idea, popularly held, that electricity is in itself a motive power. In electricity we have an agent which serves as a means for the conveyance of power, in many cases a very convenient one, and more suitable than water, air, wire-rope, or other means, for accomplishing the same object. In hydraulic, pneumatic, or wire-rope transmissions, it is only when mechanical power is supplied to the system that the water, air, or cable become, so to speak, sources of power; and in a similar manner electricity itself requires mechanical or chemical means to produce the difference of potential or pressure necessary to develop power by its agency. There are not wanting signs in this country of activity in many branches to which electrical power can advantageously be applied. From America we have reports that the motor industry is almost on a scale with that of lighting; while in France there has been for some time amongst engineers an enterprising spirit and a willingness to put electricity to the test in various industrial applications. This was to some extent made evident last year at the Paris Exhibition. The two 10-ton electric travelling cranes, although manifestly capable of improvement, were in themselves a powerful demonstration of the facilities offered by electrical power for this class of machinery. One point which could be remedied by altering the ratios of gearing was in the speed of travelling, this being only at the rate of some 95ft. per minute with the fastest gear, or less than half what is usually required. The cranes did excellent work both in erecting and removing machinery, but the painfully slow process was more particularly felt at the removing, many firms having to wait their turn to get their machinery moved to the railway lines. Some interesting points were elicited from the experience gained in the working of these two cranes, which were on entirely different systems. There were one or two exhibitors showing machine tools driven electrically, and some very handy forms of electrical winches and vertical cranes. Perhaps the most demonstrative pieces of electrical work were the transmissions of power in the Swiss, French, and American sections. These were on no small scale, the Oerlikon Works alone driving 200ft. of shafting electrically, and this supplied the whole of the Swiss and part of the Belgian section. Close on 200 horse-power was taken off on this shafting for driving a number of looms, flour mills, brick and tile making, silk weaving and other machines. The plant consisted of a 250 horse-power dynamo and motor of the Oerlikon 4-pole build, working at 600 volts. These machines had armatures of Gramme type measuring 22in. in length and 37in. outside diameter. Another transmission was by Marcel Deprez machines, which convey considerable power to the remotest part of the Exhibition for running agricultural machinery; and another transmission covering the same distance by an aerial conductor was done by Thomson-Houston machines, delivering about 45 horse-power, at a working pressure of 500 volts. It is somewhat surprising that nothing of the kind was attempted at Edinburgh this year. The telpher line electric tram and launch and the driving of some sewing machines were the only conspicuous examples of the employment of electrical power.

In the cranes and windlasses mentioned above the general practice seemed to be to allow the motor to run continuously in one direction, supplying its power in most cases to a countershaft. From this again power could be taken off as required, and in the case of a travelling crane in any of the three directions required.

Various methods were noticeable in different exhibits for throwing the motor in and out of gear, and for reversing. Amongst these the types of portable cranes and winches shown by M. Guyenet, of Paris, were fitted with very handy gear. In one case, that of the crab or winch, the motor was movable bodily about a central axis through its bedplate, parallel to the armature shaft, and at either end of its shaft were fitted 3½in. friction pulleys. The hauling-drum was mounted centrally on a separate shaft, at either end of which were fixed 4ft. pulleys, having 4in. grooves or slots recessed in their inner faces. The small friction pulleys on the motor spindle engaged within these recesses, and by the amount of play allowed (about ¼in. each way), it was only necessary to rock the motor by a very slight amount in either direction about its central axis, to cause the friction pulleys to engage with either the outer or inner sides of the recesses in the large pulleys, and consequently start the winding drum revolving in one direction or the other. By one-hand lever the drum could be thrown in gear and run either way according to the way the lever was turned, and whichever way this was turned the counterpoise of the brake was raised and the brake released; also when the lever was let go the counterweight came into action, causing the brake to grip the wheel again and the lever to be restored to the neutral or off-gear position. In the hands of an ordinary workman, therefore, the control of such a machine would be of the easiest possible description. Instead of one hand being employed in managing the steam admission valve for stopping and starting, the other hand for the reversing lever and the foot for the brake as in the case of a steam winch, only one hand was required. By means of the large pulleys in which the small friction pulleys on the motor engaged, the necessary reduction of speed between the motor and hauling-drum was effected in a simple manner. The machine was designed for raising a load of 3cwt. at a speed of 200ft. per minute, and therefore would exert 2 horse-power effective. The motor speed was from 1,200 to 1,500 revolutions.

The portable crane exhibited by the same engineer was specially designed to be employed in stacking bales, an operation which ordinarily takes so much labour and time in grain, wool, and sugar warehouses It consisted essentially of an upright post of channel iron, supporting at the top the jib and counterpoise and mounted for convenience on a trolley, on which it was capable of turning on a vertical axis. The motor ran a small countershaft by belting, which, by another belt, drove the winding drum. This second belt was normally loose, the pulleys being double-flanged to keep it in place, and the throwing-in gear was effected by tightening the same. A third flanged pulley was employed to effect this by taking up the slack. The whole control of the crane was manipulated conveniently by a cord, on pulling down which a lever was raised which first released the brake and then tightened the belt. The load was then lifted, and at any required height stopped by letting go the cord. Similarly, for lowering loads the cord was held with sufficient tension to release the break to the necessary degree but not sufficiently to tighten the slack belt, a perfectly simple means of control. Up to last year, these appliances had been in pretty extensive use in different warehouses in Paris, Rouen, Havre, Tergnier, and Roubaix, and at wharves for the purpose of unloading and stacking goods. There must be many cases in which the portability of power in this manner would be of great service in warehouses and factories. Instead of fixtures like steam-piping and counter-shafting, a couple of well insulated leading wires are all that is necessary to follow the machine about to any spots where power is required.

In overhead travelling cranes driven electrically the most convenient practice is to fix the motor on the crane girders at one end, and connect it by speed-reducing helical or friction wheels to a shaft, which may be termed the power shaft, lying parallel to the direction of the track. This shaft carries nests of bevel or friction gear, which, controlled by suitable levers, transmit the motion to one or all of the separate motion shafts in either direction. The electric current must be in connection with the motor all along the track, and for this purpose a bare conductor laid along the track on one side is necessary. The Paris cranes were each worked by two bare copper conductors, No. 5 B.W.G., one for the return circuit, and these were laid on porcelain reel insulators, but not fixed thereto. On the cranes gun

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metal hooks bolted to wood blocks were fixed at one end, and the bare conductors rested in them. The hooks were adjusted at such a height that the conductors were lifted off the reels as the cranes passed, and this slight upward pressure produced a good rubbing contact. Stranded cables were tried first, but the continual rubbing caused the strands to part. Mr. E. W. Anderson, M.I.C.E., in his electrically driven 20-ton crane at the Erith Iron Works Foundry, put up lengths of 2in. angle iron for his conductor. These lengths were connected electrically by copper staples, and the whole mounted and insulated on wood blocks along the track. Continuous rubbing contact was made with this conductor, which was ground up on one face, by means of brass blocks carried on the crane, and pressed against the conductor by a flat spring. In this crane the return circuit was made through the rails of the track, contact being effected by a wire brush rubbing on the rail, and connected to the body of the crane and one of the wheel axles. This arrangement was found by Mr. Anderson to be very reliable in action. In his crane the motor and dynamo were shunt-wound, resistances being used for regulation in the armature-circuit of the motor, but its field being always in circuit and excited. When the crane, which itself weighed 18 tons and covered a span of 39ft., was travelling along the track at the rate of nearly 84 feet per minute, with a load of over 19 tons on the hook, the motor absorbed close on 7 electric horse-power, the current supplied being 46 amperes. The dynamos and motors on both of the cranes at Paris were series-wound, and the starting and stopping of the motors effected through multiple switches, which gradually introduced or withdrew resistance. In these cranes the current absorbed was from 25 to 28 amperes, when travelling at 95ft. per minute along the track, and carrying a load of 8 tons, though, of course, at starting it frequently reached double that amount. The motors were capable of giving out 12 horse-power effective, but not more than one-third of this was taken off with the above load. The cranes were used during the Exhibition for the conveyance of passengers; and the above load, which represented about 120 persons, was an evenly distributed one. The weight of each crane was 30 tons, the spans being 59ft. The series-wound dynamo supplying current to the Mégy crane had an additional winding on the field taken as a shunt from the brushes in order to prevent the machine reversing when the speed of the motor suddenly increased.

With reference to the mechanical gear the last-mentioned crane was fitted with an excellent form of friction clutch, which also served the purpose of imposing automatically a safe limit to the load put on. Briefly, each bevel wheel in the nest gear on the power shaft was enlarged on one side, in form like a pulley of the same diameter, loose on the shaft. Inside this pulley, with a bearing surface equal in width to its inside face, was a steel spring faced with leather, and fast with the shaft. The manner of mounting this on the shaft and controlling its action on the pulley was as follows: A sleeve keyed to the shaft supported the fulcrums of two levers fixed at right angles to the shaft, the short arms of which were jointed to the free ends of the spring, and the long arms provided at their ends with rollers between which a wedge could be conveniently forced in or withdrawn. The wedge was carried by a collar which could be shifted along a feather on the shaft by a forked lever. When the wedge was introduced between the long arms of the levers the short arms approached each other and compressed the spring, leaving the pulley free; and when withdrawn the spring became expanded so as to grip the pulley with any predetermined amount of frictional adhesion, and run it fast with the shaft. One collar carried two wedges, one for each bevel wheel in the nest; and when in a central position between the two the wedges were inserted within each pulley, so that both ran loose, and either one was put in gear by moving the lever, so as to withdraw the wedge from that pulley. On the main hoisting gear, which was conveniently fitted with single and double purchase gear, one of these springs was fitted within a pulley, that is to say, the power used in hoisting a load was all transmitted through one of these internal springs. Slip would occur if the load exceeded the maximum allowable, and the crane thus refuse to raise a load exceeding a predetermined safe limit. The levers controlling the three directions of movement and the two changes of speed were all worked from a platform below the crane body on one side; but they could also be worked from the floor level by chains, as in hand-power cranes. This is more essential for erecting-shops, where often a very slow movement is required, such as in lowering a cylinder on to its studs, and these slight movements are best controlled by a man on the ground close to the work. For foundry work this is, of course, not so necessary.

Messrs. Mégy, Echevarria, and Bizan, who were the makers of the above crane, had installed up to last autumn a 25-ton electric crane for the engineering firm of Farcot and Co., also two 6-ton cranes for the printing machine works of Marinoni.

The gear on the other crane, that of Messrs. Bon and Lustremant, was entirely by friction pulleys, both for the nests and for fast and slow speed gear. The surfaces were faced with paper, leather having been tried and found wanting. Upon throwing into gear, the slip which occurred before actual grip took place was an advantage in preventing any sudden strains. In this crane worm gearing was interposed between the power shaft and the separate motions with good results. The hoisting chain was anchored at one end of the crane, whence it passed over the pulleys, and falling block on the carriage to the driving shaft at the other end. On this shaft it was wound round through link guides which only permitted it moving as the shaft revolved, and the slack was contained in a long tubular guide. The above firm had installed up to last autumn a 20-ton crane of 50ft. span on this principle, with Gramme motor at the Canon Foundry of Bourges, and one of 8 tons and 104ft. span for the Great Eastern Railway Company's shops at Romilly, used for unloading trucks and stacking.

Whatever comparison may be drawn between the rope, square shafting, and electrical methods of driving overhead cranes, there appears to be a decided advantage in the electrical method over that in which the crane carries its own steam engine and boiler. The dynamo generator can be put down in the most convenient part of the works, and the necessity for raising fuel and water to the crane, and lowering ashes done away with. Also the engine driving the dynamo being supplied with steam from the works' main boilers, avoids the expenditure of time otherwise taken in getting up steam on the crane. For driving by square shafting, or rope, the engine must be either in the same shop with the crane or not very far away; at any rate, the crane must be within reach of countershafting, while in the electrical method the source of power, the dynamo, with its steam engine, may be placed anywhere most convenient, and its power used for motors in other parts of the works. In cases also where the crane rails are affixed to wooden staging, or inflammable material is being dealt with, and corresponding risk is incurred by the use of self-contained steam cranes, there seems to be a special field for the application of electricity. Mr. Crompton's first electrical travelling jib crane was designed to take the place of self-contained steam driving, which, by the nature of the staging and surroundings where the crane was at work, occasioned considerable risk.

THE CENTRAL STATIONS OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.

BY DR. J. A. FLEMING, M.A.

(Continued from page 707.)

The arrangements in the dynamo room for effecting all the necessary interconnections and changes between dynamos, exciters and feeders, have been elaborated with great care, and the arrangements at Sardinia-street are the outcome and final result of an immense and expensive experience in other places. The process of evolution of machinery is always, or almost always, from the complex to the simple, the process of discarding or shedding off unnecessary organs, and reducing the parts to the fewest possible, is one in which advance shows itself.

On entering the dynamo-room of the Sardinia-street Station, we are struck at once by the immense and handsomely

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finished switchboard. It occupies a great part of the length of one side of the dynamo-room, and is about 54 feet long, and 11 feet in height. It stands away from the wall by about a couple of feet, allowing sufficient room for workmen to pass behind it, and to make or renew all the multitudinous connections which are made by highly insulated cable behind this board. The front of the switchboard is divided into twenty panels, the base of each panel being of enamelled slate framed in polished wood. From the dynamo-room proceed twenty feeders, or primary mains, and as there are ten alternators and three exciters, the combinations which have to be effected are as follows:—(1) Any group of alternators must be capable of being excited by any exciter. (2) Any one or group of feeders must be capable of being worked off any alternator or group of alternators. (3) Any given alternator must be capable of being made the "stand-by," or reserve machine, to any working dynamo or group of dynamos; and, lastly, any group of alternators must be capable of being worked in parallel together on any primary main or mains. (4) All these changes have to be made instantly, certainly, and without confusion, by one person.

We shall best explain the principle on which this is done by giving a diagram and description of *a small portion* of one half of a single panel of the switchboard. We shall limit our attention to a combination, first, of a single feeder and three alternators, and show how these changes are effected. Referring to Fig. 6, let 1, 2, 3, 1^1, 2^1, 3^1, be the leads from three alternators, No. 1, No. 2, and No. 3. These leads are terminated on brass plug blocks, a_1, b_1, c_1, a^1, b^1, c^1, fixed on the panel. On either side of this group of blocks are four common

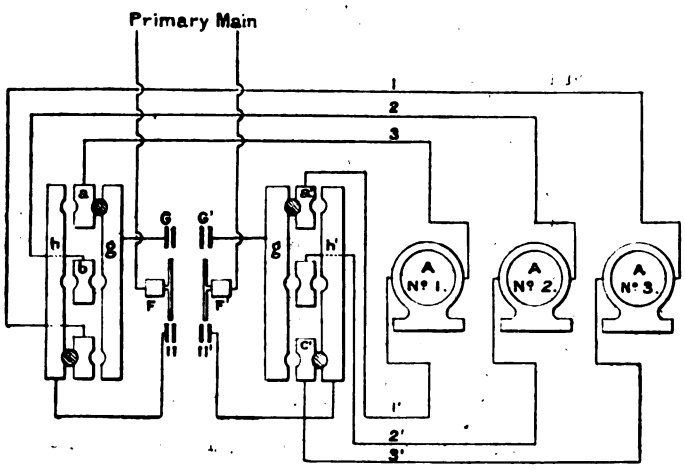


FIG. 6.

bars, h_1, g_1, h^1, g^1, and plugs can be inserted in the holes to connect a_1, b_1, c_1, &c., with g_1, h_1, &c. The primary main F_1 F^1 terminates on the centre of a duplex double-pole switch between the bars. When this switch is thrown up it connects F_1 F^1 with bars g and g^1. When it is thrown down it connects F and F^1 with bars h and h^1. The handle of this switch has three positions in which it will stand firm: 1st, one in which F and F^1 are both disconnected from G and G^1, and also from H and H^1. 2nd, an upper position, or one in which F and F^1 are connected to G and G^1; and 3rd, a lower position, or one in which F and F^1 are connected to H and H^1.

This being understood let us suppose that plugs are inserted in the four holes marked with a shaded circle, and let the centre switch be in the upper position. Then alternator 1 is connected with the primary main F, F^1, and may be considered to be working on it. Let alternator No. 3 be kept turning slowly round, and let us suppose something goes wrong with No. 1 machine. The engineer simply calls down for the alternator No. 3 to be run up to full speed, which can be done in a few seconds. He then snaps over the centre switch from top to bottom position, and the instant result is that the main line is changed over from machine No. 1 to machine No. 3. Let us also imagine that it is required to run alternators No. 1 and No. 2 in parallel, and to have No. 3 as a reserve. This can be effected by putting plugs in the holes joining blocks b and b^1 to bars g and g^1, in addition to those already in.

This being clear, all that remains to be said is that at Sardinia-street each semi-panel of the switch board contains two such rows of ten blocks, like a, b, c, &c., and four bars like g, h, g^1, h^1, and a centre switch, as shown in Fig. 7.

Each complete panel is the double of this, and supplies a pair of primary mains, making the two to each dynamo, and the ten double panels correspond to the twenty mains. On looking at the board when the dynamos are working we see a set of plugs plugged-in to join the dynamo blocks a, b, c, &c., to the omnibus-bars g g^1, &c., and we see a plug in the corresponding holes of all the panels, which is the plug belonging to a spare machine. We can thus have the feeders grouped in any way

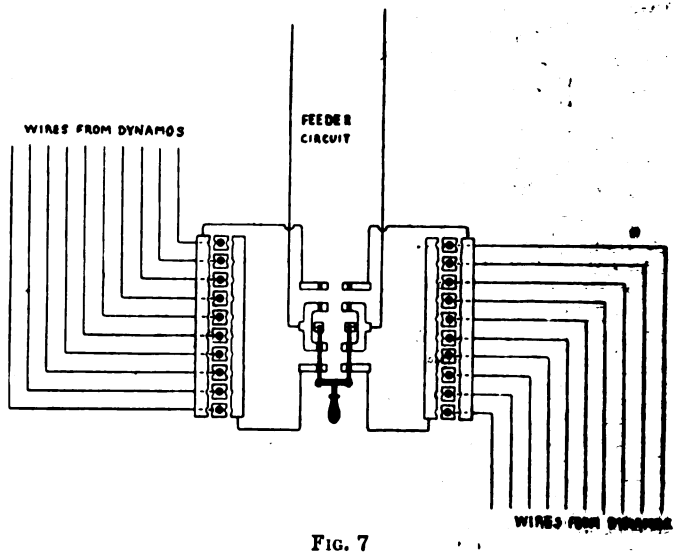
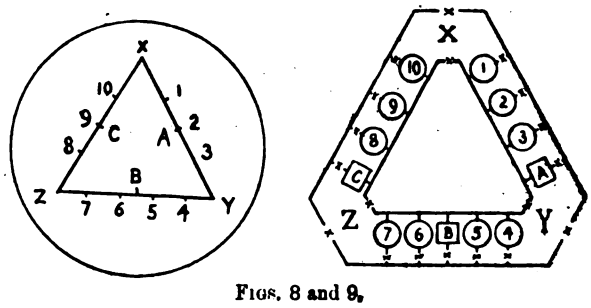


FIG. 7

on the working dynamos, and we can have a spare machine which, as it were, waits on all of them, and is ready instantly to take the place of any working machine that gives out. Thus we may suppose five feeders—1, 2, 3, 4, and 5—are working off dynamos No. 3, 7, and 9 grouped as follows:—No. 3 works feeders 1 and 2, No. 7 works feeders 3 and 4, and No. 9 works feeder 5. Also let dynamo No. 5 be a reserve machine turning slowly round. If No. 3 dynamo were to be found to be getting hot bearings, No. 5 reserve would be started up, and switches of panels No. 1 and No. 2 thrown over. The reserve machine could then step into the shoes of No. 3. Or, if No. 3 machine were to be found to be overloaded,



FIGS. 8 and 9.

one of its feeders, say No. 1, could be thrown over on to a reserve machine. It will thus be seen that the possible combinations are endless, and that the engineer need never be in a "tight place" by reason of not being able to re-adjust the load, or to relieve a particular machine unequal to its work.

We have next to describe how the exciters are coupled in. This is rendered plain by a diagram of connections engraved on a brass plate and fixed to the switchboard. This diagram is given in Fig. 8. The connections are shown in Fig. 9.

Let three pair of mains be arranged between three double pole switches, X, Y, and Z. When all these switches are closed it forms a closed circuit. Between these mains are joined in parallel all the armatures of the three exciters A, B, and C, and

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all the fields of the ten alternators, each, however, being capable of being cut out by its own private double pole switch. It will then be seen that by suitably closing the private switches (marked by a small cross in the diagram), and by manipulating the switches X, Y, or Z, that the exciters can be used to excite any group or groups of the alternators in a very varied manner. The five centre panels of the switchboard are devoted to these exciter switches, and the centre panel of all has on it the switches X, Y, and Z. If, therefore, anything goes wrong in the dynamo-room, the engineer in charge flies to the centre panel of the board. From this spot he can see the whole dynamo-room, and every dynamo has its number painted conspicuously upon it. Hence he can see at once what to do to take that machine out of circuit.

Over each panel of the board and in connection with each primary main is an amperemeter, a voltmeter and the voltmeter compensator. This last device which enables the voltmeter in the station to read the volts at the far end of the primary main has already been fully described (*see The Electrician*, Oct. 17, 1890, p. 678).

There is also a standard station voltmeter, by which all the others are adjusted. Underneath the panel there are the variable resistances to be inserted in the field circuit of each alternator as required, and the resistances to be inserted in the field circuit of the exciters for regulating the exciting current. By these resistances the exciting field of any alternator can be controlled independently of all the rest, and the volts at the far end of its associated mains kept to the standard voltage. Also by the resistances in the fields of the exciters the electromotive force of any simultaneously excited group of alternators can be raised or lowered as required. It will thus be seen that a vast amount of thought and skill has been brought to bear on the design of these arrangements with the object of reducing to a minimum the labour required.

The distributing system of mains in connection with Sardinia-street is an underground system. Highly insulated leads, covered with vulcanized indiarubber, are drawn through iron pipes laid under the footways or roadways. The joints in the cables are vulcanised *in situ* by means of a small portable heater. So far this system has given every satisfaction. It is practically very similar to that which has proved itself successful in connection with the House-to-House Station at West Brompton. Westinghouse transformers are used, placed in suitable positions inside or outside of the buildings to be lit, and these transformers, used in about five sizes, transform down from 1,000 to 50 volts. When these stations are all complete, it is in contemplation to connect them together by trunk mains, so that one station can help the other.

It only remains to add that the current is supplied by meter, and that the Shallenberger meter is extensively employed.

(To be continued.)

ON KINETIC STABILITY WITH MAGNETIC FORCES.*

BY PROF. G. F. FITZGERALD.

If a perfect conductor move near a magnet there are currents induced in it which tend to stop the motion. If the conductor be perfect, the kinetic energy of motion will ultimately, if small enough, be all changed into electro-kinetic energy, and the conductor will begin to move in the opposite direction, and when in its former position its electro-kinetic energy will have been reconverted into kinetic energy. For instance, if a perfectly conducting shell were placed near three magnetic poles it would be in a state of kinetic equilibrium if the energy given to it by a small disturbance were not great enough to drive it to infinity, or into contact with the magnet. It is to be remarked that I have assumed the perfect conductor to have been brought within a finite distance of the magnet pole without having had currents induced in it, *i.e.*, I have assumed that the body can be brought up as an imperfect conductor, and then changed into a perfect conductor *in situ*. As the effect of a magnetic pole is to induce in a perfect conducting plane sheet currents which can be magnetically represented by a pole at the reflection of the first pole in the sheet, it follows that with a perfect conducting sheet there would be no action such as, in Arago's experiment, prevents motion of the sheet parallel to itself. There would, no doubt, be a gradual radiation of the energy due to the varying magnetic field. This would have a damping effect on the vibrations much the same as would result from resistance in the conductors.

The system is interesting as an illustration on a large scale of how meteoric swarms have their energy gradually frittered away into electro-magnetic radiations.

* Abstract of a Paper read before the British Association in Section A, Leeds, September, 1890.

REVIEWS.

Sound, Light, and Heat. A Class Book for the Elementary Stage of the Science and Art Department. By J. Spencer, B.Sc. London: (Percival and Co., 1890).

The Science and Art Department are undoubtedly to blame for tempting their teachers to write such books as these. They arbitrarily select certain physical phenomena and brand them "elementary." For a student who is to study acoustics without learning anything of timbre, a representation of a sine curve by a few semicircles is thought good enough. In so small a book there appears to be no room for the common-sense explanation of refraction by the principle of retardation; but being written by a schoolmaster, the law of sines must come in. The book contains several such careless statements as "By heat we mean the sensation of warmth." This class of literature might be checked by a censorship for all books which refer to the Department, in either title page or preface.

Magnetism and Electricity. A Class Book for the Elementary Stage of the Science and Art Department. By J. Spencer, B.Sc. (London: Percival and Co., 1890.)

This book is but little better than the above. The arrangement of the matter in "experiments" is not justified by any increased clearness or convenience. A great deal of space is filled with questions. The subject has been dealt with by others in a much more satisfactory manner, and we therefore cannot see any reason why it should have been written.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

MONDAY, November 3rd.

ROYAL INSTITUTION.

3 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7.30 p.m. Ordinary Meeting. Paper to be read on "The Treatment and Utilization of Exhaust Steam." By PERCY GRIFFITH.

TUESDAY, November 4th.

CITY AND SOUTH LONDON RAILWAY.

12.30 p.m. Opening of the Line by H.R.H. the Prince of Wales.

ROYAL VICTORIA HALL.

8.30 p.m. Lecture: "Old Buildings and the Story they tell." By ARNOLD MITCHELL.

THURSDAY, November 6th.

CHEMICAL SOCIETY.

8 p.m. Meeting.

OLD STUDENTS' ASSOCIATION.

CITY AND GUILDS OF LONDON INSTITUTE.

8 p.m. Ordinary General Meeting at Finsbury Technical College. Presidential Address on "Industrialism." By W. B. ESSON.

FRIDAY, November 7th.

INSTITUTION OF ELECTRICAL ENGINEERS.

7.30 p.m. Students' Meeting.

ELECTRO HARMONIC SOCIETY.

8 p.m. Smoking Concert at St. James's Hall.

***** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.**

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SPECIAL NOTICE.

The present Number of "THE ELECTRICIAN" completes Volume XXV. With next week's Number will be issued (gratis) the Index to the Volume.

THE LOCAL AUTHORITIES AND ELECTRIC TRAMWAYS.

We have had reason to observe, on more than one occasion recently, that among the difficulties which electric traction has to surmount in this country, opposition on the part of Local Authorities cannot be counted as the least. Indeed, it has been roundly asserted by promoters, and even hinted at by the Press, that the "Vestries," under which designation is included local Corporations of almost every kind, have blocked the way from interested motives, or because their interests have not been squared by a judicious employment of fees. We ourselves attach no importance to these insinuations, which are a trifle too self-righteous in the mouths of those who make them; our belief being that where there are people who can be corrupted, there are always plenty of others to corrupt them—if it is worth while. And the fact that the Local Authorities have maintained their original attitude of hostility is pretty strong proof that either they are incorruptible, or that the friends of electric traction have not the courage to back it with their money. Probably the real cause of the deadlock is something not quite so simple, but a good deal less discreditable. No one can regret more than we do the little headway which this branch of electrical industry has made since its practicability was fully demonstrated. But nothing is to be gained by imputing bad motives, especially those of a personal kind; whilst, on the other hand, if the real reasons are discovered and fairly considered, it may be possible to arrive at a friendly understanding or a working compromise satisfactory to both parties.

It must be confessed, however, that the action of Local Authorities, who have so often, though not, as has been alleged, invariably opposed the introduction of electric power on tram lines, is somewhat obscure to the outsider. Not improbably the real explanation is better known to the electrical promoters than

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they care to own; and, if that is the case, we should recommend them to take the public into their confidence, and trust to the soundness of their case, if it is as sound as they represent. Anyway, it is no use railing at the Vestries, who, say what we will, have the power vested in their hands for the good of the ratepayers; and who, therefore, if they cannot be conciliated, are not likely to be won by exasperation, or by imputations of bad faith. Certainly the case of the Hammersmith Vestry, mentioned in our columns a couple of months ago in connection with Mr. Lineff's project, was somewhat incomprehensible, the adjoining Vestries having supported, and the Board of Trade and London County Council having sanctioned it. Possibly some local reasons of a more or less legitimate sort may have determined the Hammersmith Vestry to remain obdurate. But it strikes us as rather odd that having secured such powerful support outside Hammersmith, the promoters had not the good fortune, or shall we say the good management, to overcome the one remaining obstacle. Moreover, if the area in question was the one chiefly concerned, it need not surprise us that the cheap approval of outside areas, and the imprimatur of the Board of Trade counted for very little in the eyes of the Hammersmith Vestrymen. They may be supposed to know their own local affairs best; and local circumstances may often very properly have great weight as against general principles. The question is, are these local considerations of real import? When they are so, it will be wise to let them alone, rather than try to force an experiment on unwilling clients. If, however, the objection is groundless, it will be the business of the electrical engineers to prove it to be so by argument and demonstration, and not by abusing the particular local Vestry for having acted independently on its own convictions.

To what extent the foregoing remarks apply to the case of the West Ham Local Authorities in their dealings with the North Metropolitan Tramway Company's scheme for introducing electric traction on their lines, we are not prepared to say; but it must be owned that an explanation from West Ham is very much needed, its conduct as described by the other side being altogether indefensible. It will be remembered that the Tramway Company obtained consent from the authorities to try the Electric Traction Company's system on the Barking section for one year, subject to a 24 hours' notice to quit. The Companies were satisfied with the experiment, and authority was asked and obtained of Parliament to work the whole of the North Metropolitan tram-lines under a licence for seven years. As the power of summary notice was never exercised by the West Ham Authorities, one would suppose that they too were satisfied. But now that Parliamentary sanction is obtained, they positively refuse to extend the permission except on the same conditions and for the same short period as before. The sanction of the London County Council has not yet been obtained; but when it comes, as probably it will, its effect at West Ham may be conjectured from its failure in West London. Of course the Tramway Company cannot proceed on such conditions as these; and there is consequently a very discouraging outlook for what at one time looked like a highly promising field of electric traction operations. The example of West Ham may possibly prove infectious, and in that case the Parliamentary Licence will be wholly confiscated. Were Sir WILFRID LAWSON chairman of the West Ham Vestry, and electric traction a species of intoxicant, its treatment could hardly have been worse.

It is hard to believe that the Vestry can be dissatisfied with the result of an extended trial which so greatly encouraged the Tramway Company; and as a renewal of the earlier licence for one year is offered, we may fairly assume that there are no local objections peculiar to West Ham, and fatal to the system. We are driven, therefore, to the surmise that the true explanation will be found in the proviso of the Parliamentary Licence making it conditional on the consent of the Local Authorities. As in the case of Electric Lighting, this saving clause has inflated the self-importance of the Local Authorities, who, being thus able to give or withhold at their pleasure, esteem it their interest to keep a tight hold of a new industry lest it should expand beyond their reach if left to itself. In short, the Local Authorities are everywhere on the look-out for undertakings which can be brought into the parochial sphere; and as the Tramways Companies' concessions are gradually falling in, they are considered fair game for the modern communistic Vestry. There is no gainsaying the tendency; and we can only recommend our friends to accept the fact and act accordingly. It means, first of all, that the field for financial operations in connection with electrical industries will be to this extent restricted; but it does not necessarily follow that the industries will be crippled. On the contrary, if they are good for anything they have only to prove it, and there will be plenty of work for them to do. As regards electric tramways in particular there is no serious opposition to them as such; they have succeeded elsewhere; and the steps now being taken by the Glasgow Corporation serve to show that where the system can be taken over by Local Authorities it will be included in their programme of public works, and will certainly be tested on its merits. The fact above alluded to that the tramway concessions are expiring may be bad news for promoters; but that would be the case even if there were no electric traction to compete with horse power. It is not of bad omen for electrical power, for an opening will be created to try what it is capable of doing under the special conditions imposed upon it in this country. Those conditions are far more exacting here than in the United States; but if they can be complied with, there is no reason to fear that either any prejudice on the part of the public, or interested hostility on the part of the Local Authorities, will long hinder the natural development of this new and important addition to our powers of locomotion.

THE STATIONS OF THE WESTMINSTER ELECTRIC SUPPLY CORPORATION.

The lighting of Westminster, where engineers "most do congregate," ought to be well done; but until recently the attempts which have been made in the neighbourhood of Victoria-street, the street of electrical engineers, have not been very promising. Two concerns, not counting the now extinct Maxim Company, and the private plant at No. 100, for some time supplied current for a small number of lamps. One of these, the City of Westminster Electrical Syndicate, supplied both direct and alternating current by overhead wires. The Westminster Electric Light Corporation having at that time a small plant in Dacre-street, put in an appearance at the Board of Trade inquiry, and eventually absorbed the rights which the Syndicate had acquired, the most important of these being the lighting of the Houses of Parliament, and the site for a station in Millbank-street, with a river frontage. Fortunately both for the shareholders of the Company and for the future consumers in the large district which has been allotted to it, Prof. A. B. W. Kennedy, F.R.S., accepted the post of engineer, in January last, and under his direction the work has been thoroughly organised, and the design and erection of the stations, together with the planning and laying of the mains, have been making rapid progress. The district, as most of our readers who are interested in the lighting of London are aware, contains the whole of those parts of Westminster and Pimlico between the District Railway and the river, and at its western part extends northwards so as to cover all Belgravia and Mayfair as far as Oxford-street

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The stations will be three in number. The first, taking them in the order of commencement, is the river-side station at Millbank-street. The general arrangement of the station, which had been commenced before Prof. Kennedy assumed his present position, and which has since been modified in certain particulars, is shown in Fig. 1. The boiler-house contains three Babcock-Wilcox boilers, with room for six more; two alongside of the three which are now at work, and four facing them, with an 11-foot stoking floor between. The working pressure is 160lb. per square inch. An upper floor will form a coal store, the coal of course being brought by water. For the present, the coal will be stored on vacant parts of the boiler-house floor. A Green's economiser is arranged in the main flue. Two main steam pipes run across the top of the boilers, and valves are provided by which any boiler may be connected to either pipe.

Passing to the engine-room, the pair of steam pipes deliver into a ring main through a set of valves with a connecting branch which allows for every possible combination. The ring main is composed of sheet steel welded pipes with copper bends. It has been found to expand one and a-half inches under steam test, and will be suspended freely by links from the level of the traveller girders. A condenser is being set in the engine-room, beneath the floor of which the exhaust steam pipes are laid in chases in the concrete. At each end of the room is a switchboard made by Crompton and Co.; one devoted solely to the House of Commons circuit, and the other for the general purposes of the station. The machinery at present in the engine-room consists of two 45-unit Goolden dynamos, with Willans central valve engines, to which will be added, in a few weeks, the two similar machines which are now supplying the Houses of Parliament; and also two Edison-Hopkinson dynamos, of 112 units, with Willans 200 horse-power engines.

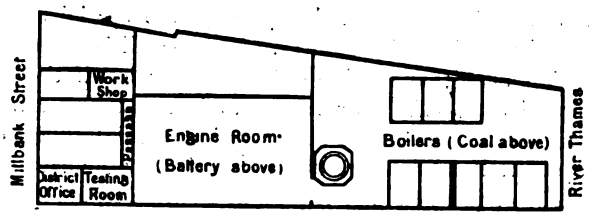


FIG. 1.—St. John's Wharf Station, Millbank Street. Scale, 64 feet = 1 inch.

Above the engine-room is a battery-room. This is practically ready for the reception of the batteries, one set already having been delivered. The batteries will be of the Crompton-Howell type, and each set will provide for a reserve of 500 ampere hours. In this, as in the other sections of the Westminster Company, the batteries are intentionally placed in this position rather than on the ground or in a basement, in order that they may be kept warm, since it has been clearly ascertained that they work better at a fairly warm temperature. At the end of the battery-room a portion is shut off by a partition for the reception of the regulating switches, thus saving the use of an unnecessary quantity of cable. This switch-room will, of course, have independent ventilation. Access to the upper floor is had by means of a stairway winding round a steam-exhaust flue, the architectural arrangement forming a somewhat remarkable feature at the end of the road which runs down the side of the engine-room. The mains run into the basement of the house of the resident engineer through iron tubes, and pass into a space below the floor of the testing-room at the back of this house. This room will contain the terminals of mains and feeders, and will at the same time be used as a testing-room for the circuits and for meters.

The engine-room at Dacre-street has been considerably improved of late, and the two Crompton dynamos and Willans engines are now snugly arranged beneath a gallery containing the switchboard; the whole having the air of an engine-room on board ship. A set of Crompton-Howell accumulators, of a capacity of 500 ampere hours, provides for the lighting of Victoria Mansions, the neighbouring residential flats and hotel, together with other circuits, which extend as far as the west end of Victoria-street, and Messrs. Peto's works in Pimlico. The ordinary full load is now about 600 amperes at 102 volts. This little station will disappear as soon as the current can be supplied from the other stations.

The second station of the Company is situated in Eccleston Place, and is only in an early stage of building at present. The arrangement is shown in Fig. 2. The engine-room and boiler-house are side by side. The batteries will be over the boilers, while a workshop will be arranged over the engine-room. The chimney is situated so as to allow a minimum length of flues. Multitubular boilers by Davey Paxman and Co. will be used, and Crompton dynamos have been ordered. These will be driven by Paxman and by Willans' engines, working at 150lb.

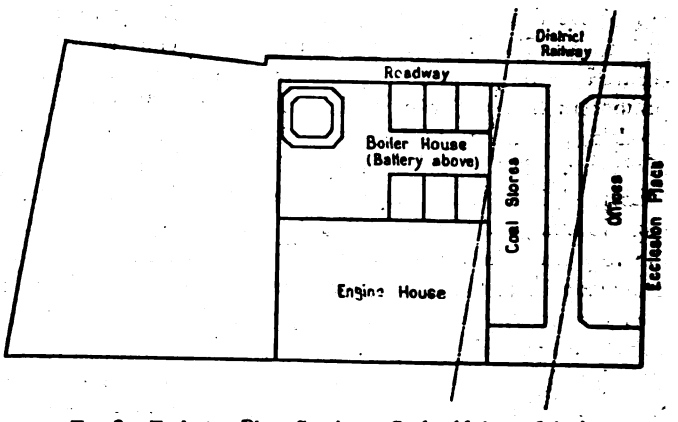
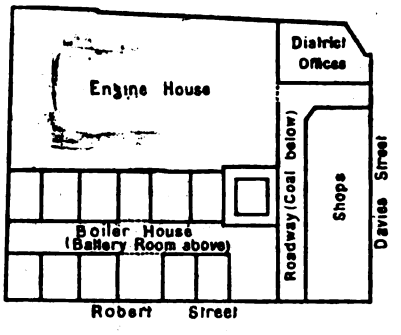


FIG. 2.—Eccleston Place Station. Scale, 64 feet = 1 inch.

per square inch. The machinery and batteries, which will be put down at first, will provide for about 900 indicated horse-power. The batteries (Crompton-Howell type) will each have a capacity of 500 ampere hours. In order to avoid the unloading of coal in the streets, a road is being constructed, as shown on the plan, and a coal store will run alongside. Later on it is proposed to build offices with a street frontage. On this station will depend for its supply the residential quarter of Belgravia and the adjoining streets. The demand in the best parts will, undoubtedly, be heavy at times, but only during the season, a large number of the better houses being shut up for many months in the year. The building operations are proceeding rapidly, and it is expected that current will be supplied from the station early next year.



Davies Street Station. Scale, 64 feet = 1 inch.

The third station will supply Mayfair and the northern part of the district. The arrangement is shown in Fig. 3. A roadway running behind is provided for coaling, a portion of which is let for shops in Davies-street. The coal storage will be below the road, as in Sardinia-street. The boilers are of the multitubular dry back type, working at 160lb. per square inch. The boiler-house is bounded by Robert-street, the engine-room being at the back. The machine ordered for this station provides for, practically, the same output as at Eccleston-place, and is of the same general type. Dynamos are being made for it by the Electric Construction Company, and by Messrs. Siemens. It is expected that current will be supplied from it early next year.

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The mains are already laid in about ten miles of streets, and the work is being actively pushed on at several points. The system adopted in Westminster, where Messrs. Crompton and Co. are contractors, is that used by Mr. Crompton in Kensington. In other parts of the district, Messrs. Mowlem are laying mains on a system devised by Prof. Kennedy, in which the copper strip is simply laid on glass or stoneware insulators, and not permanently strained up. When there is not room for concrete culverts and bare strip, Henley's and Silvertown cables are being laid in Callender-Webber casings, and under similar circumstances Siemens' cable is being used for feeders.

The progress of the work under Prof. Kennedy's able *régime* has been very remarkable, and there seems to be every prospect that an extensive and thoroughly reliable supply will be provided in a few months. At present, of course, the three-wire system is not being used, but feeders are extensively and systematically employed, though some of the feeding points are not in their final position. There will be a complete double network throughout the district, and communication will be made by Piccadilly between the two portions into which it is divided by the Parks.

As the current registered is already greater than can be supplied by the small plant at Dacre-street, one of the dynamos at Millbank-street is already working into the same circuit. The Dacre-street machines supply current in parallel with a battery; the Millbank-street machine is connected direct into the system at a feeding point without any battery, the cells at Dacre-street serving perfectly as an "electrical flywheel" to the whole network. Of course the working is guided by the use of potential leads back from the feeding points. The arrangement works perfectly, with none of the pulsation or hunting which was predicted by some engineers from experience of dynamos running in parallel on to omnibus leads.

When the stations to which we have briefly alluded are in full working order we hope to give detailed accounts of them, and are confident that if they are finished as they have been begun, they will be well worthy of careful attention.

THE WORKING OF AN ELECTROLYTIC COPPER REFINERY.*

BY DR. G. GORE, F.R.S.

The entire economy of working depends essentially upon cheapness of motive-power and minimum investment of capital, and nearly every attempt to improve the process, in the direction of such economy, involves a choice between two evils. For instance, if we try to save horse-power by enlarging the electrodes and adding to the number and size of vats in series, we rapidly increase the loss of interest upon capital expended in stock of copper, solution, plant, working space, &c. If we increase the density of current with the intention of working more rapidly with the same stock of copper, solution, &c., we increase the loss of energy by causing polarisation, and run a risk of depositing impure copper. And if we attempt to diminish the resistance by placing the electrodes nearer together, or by quickly stirring the solution, we get dirt upon the cathodes, or short-circuiting occurs; and if we endeavour to decrease it by considerably heating the liquid, we rapidly increase the chemical corrosion of the deposited metal, and quickly alter the chemical composition of the liquid; or if we diminish resistance by large additions of acid, we promote chemical corrosion, polarisation, and separation of gases.

Difference of potential required is a large element in the economical deposition of copper. Whilst the same number of amperes of current passing through the ordinary solution deposits the same amount of copper in all cases, the necessary degree of difference of potential to overcome resistance, &c., varies in different cases; and the greater this difference the larger the cost: double the potential requires double the motive-power. It is desirable, therefore, to lower the difference of potential as much as possible by diminishing the resistance throughout the circuit, and by avoiding all polarisation and counter-electromotive force.

The degree of electromotive force required varies with every different kind of solution, and consequently of anode. It varies according as the anode is composed of pure copper, "black copper," or "copper matte," and whether the anode is clean, or covered with an adhesive badly-conducting coating; it is also much greater when gas is evolved at either electrode.

Influence of Impure Anodes upon the Liquid.—I will only speak of some of those substances which are more or less likely to be present in "black copper," "pimple copper," "Chili bars," "blister copper," containing from 89 to 98 per cent. of copper, and in cruder regulus of reduced pyrites of iron and copper. Those impurities include antimony, arsenic, bismuth, cadmium, carbon, cobalt, gold, iron, lead, manganese, platinum, silver, tin, zinc, suboxide of copper, sulphides of iron, copper, and silver in the particles of unreduced pyrites of those metals, alumina, lime, magnesia, silica, and alkalies in the enclosed portions of slag. Black copper has been found to contain "1·23 per cent. of arsenic, 1·0 of iron, ·54 of sulphur, ·4 silver, and ·011 of gold" (*Engineering*, 1885, p. 306).

In an acidulated solution of blue vitriol, the following of those substances, viz., cadmium, cobalt, iron, zinc, sulphide of iron, alumina, magnesia, and alkalies of the slag, dissolve readily; antimony, arsenic, bismuth, tin, and silica dissolve imperfectly, and partly fall to the bottom; carbon, gold, platinum, and sulphur from the pyrites are insoluble, and precipitate entirely; lead is converted into sulphate, which almost wholly precipitates; silver is changed into chloride, provided a soluble chloride is present, which is usually the case, and is entirely thrown down; suboxide of copper, and the sulphides of copper and of silver, also precipitate. The lime is all changed into sulphate, a small quantity only of which enters into solution, whilst the remainder subsides.

One effect of using an impure metal or an alloy as an anode is, that its different constituents are corroded unequally, both by the ordinary chemical action of the liquid and by the influence of the current. By both these actions the most electro-positive metals are attacked first, and the others in succession, in accordance with the thermal law which governs such actions; and those which are not corroded at all, together with those which form insoluble compounds, either remain upon the surface as a coating, or fall to the bottom as mud. In consequence of this irregularity of action, the anodes are often corroded deeply in places, even whilst containing much metallic copper in their coatings, become rotten, and pieces of them fall to the bottom, and this occurs the most with very impure metal, and especially with cupreous matte. When the anodes are made by fusion of copper pyrites, they often swell on the sides towards the cathode after a few days of electrolytic action. If also the liquid is not kept homogeneous, impure ones are rapidly corroded, and sometimes cut through at the surface of the solution and fall to the bottom.

If arsenic is present, it partly dissolves as arsenious or arsenic acid, and gradually unites with some of the constituents of the mud to form insoluble compounds; arsenious acid is sparingly, and arsenic acid freely soluble. It also partly forms arseniates upon the anode, which are non-conductors, and by adhering to that electrode offer resistance to the current.

Antimony partly dissolves, especially in acid solutions, and partly forms an insoluble basic salt, some of which adheres to the anode, oxidises and increases in weight, and some falls to the bottom; any oxy-salt of antimony appears as a white cloudiness when the liquid is sufficiently dilute.

Bismuth behaves much like tin and antimony; it partly forms an insoluble basic salt, which precipitates, and partly dissolves as an acid salt, which ultimately also becomes basic and falls.

Tin behaves much like antimony; it forms a mixture of proto-salt and basic salt, some of which adheres to the anode and some dissolves; the proto-salt is white when dry, and absorbs oxygen from the air rapidly to form persalt. The presence of dissolved tin in a neutral solution is said to greatly

* Extract from the new volume of *The Electrician* Series, by Dr. G. Gore, entitled "The Electrolytic Separation of Metals." (London: *The Electrician* Printing and Publishing Company.)

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improve the quality of the separated copper, without the tin itself being deposited; this, however, probably only occurs under particular conditions, because in some experiments I made for the purpose, this effect did not take place. The presence of tin in the anode increases the electromotive force of the current, because tin is more electro-positive than copper in dilute sulphuric acid.

Lead, being also more electro-positive than copper, is attacked before it, and aids the electromotive force; but its sulphate, being very insoluble, falls nearly wholly to the bottom, and only a trace is dissolved. There is but little risk of lead being deposited with copper, not only because its sulphate is so very insoluble, but also because lead is electro-positive to that metal. Lead, by being electrolytically corroded in place of copper, and uniting with acid to form an insoluble salt, diminishes the amount of copper and of acid in solution.

If the anode contains metallic iron and manganese, those metals are dissolved before the copper, and being more electro-positive assist the current; they dissolve as proto-salts, and subsequently become oxidised to some extent, but not completely, to persalts by contact with the air. If, however, the current is very much stronger than that usually employed in refining copper, these proto-salts are also oxidised to persalts at the anode; and in any case their persalts are reduced to proto-salts at the cathode by the current and cause great waste of power. The only way to prevent waste of energy in deoxidising persalts at the cathode is to keep those salts out of the solution. Iron by dissolving in place of some of the copper at the anode, takes up some of the acid, forms green vitriol, and diminishes the solvent power of the water and the amount of copper in solution.

Any suboxide of copper in the anode, being a non-conductor, falls to the bottom, and is subsequently slowly oxidised and dissolved as cupric sulphate by the free acid. If the anode contains much cupreous sulphide, some of it is decomposed by the current, its metal dissolving whilst its sulphur separates and subsides. If its amount is small (as it usually is in "black copper"), being a very inferior conductor it is unaffected by the current, and falls to the bottom as fast as the metal around it is dissolved.

In an anode containing copper, copper oxides and sulphides, the current goes most by the path of least resistance, *i.e.*, very largely by the metal, very little by the sulphides, and much less by the oxides. If, therefore, the anode contains very little sulphide or oxide, the whole of the current travels through the copper, and the oxide and sulphide fall to the bottom; but if it contains much sulphide, some of the current passes through it. At the same time, independently of the action of the current, the liquid is always acting chemically upon each of these substances, whether they form part of the anode or of the sediment.

It is evident that when the anode contains a large variety of impurities the chemical actions going on at its surface must be numerous and exceedingly complex, and modify each other, and make it very difficult to accurately describe them. One effect of those numerous impurities is to cause an almost infinite number of local electric currents all over the anode, attended by corrosion and solution of all the more positive substances without the aid of the external current, thus gradually neutralising the free acid, and saturating the water with metallic salts.

Influence of the Impurities upon the Current.—Provided the anodes are wholly metallic, their lower degree of electric conductivity due to impurities has very little effect upon the total resistance of the circuit, because the resistance of the solution is so very much greater. Consequently, also, it has but little effect upon the kind of dynamo required.

Impurities in the anode, however, have in some cases a great effect upon the electromotive force and upon the strength of current, either by giving rise to polarisation and counter electromotive force, or by the formation or accumulation of badly-conducting substances upon the anode. The greater the number of impurities also the greater the risk of waste of energy.

It is a fact that the electromotive force, and consequently also the strength of current, is increased when the anodes contain as impurities metals such as zinc, cadmium, manganese, or iron, which are more electro-positive than copper in the particular liquid, because they constitute with the copper cathode a voltaic couple sending a current in the same direction as the working one. But this assistance to the current, except with iron pyrites, is usually so very small that it is hardly observable, and the advantage of it is more than counterbalanced by disadvantages. The presence of iron in the anode aids the current to only a small extent, but that of zinc helps it more.

Usually when fresh anodes are put in, the resistance of the vat gradually rises to a maximum, but when the film of impurities is removed from them the resistance falls at once slightly; it also usually increases with the thickness of the coating, but only slowly because the layer is porous and saturated with the solution. The coating acts chiefly by preventing ready access of unexhausted liquid, and thus promotes polarisation.

When the solution contains persalts of iron or manganese those salts are reduced to proto salts at the cathode, and a portion of the current is continually wasted in reducing them, instead of being wholly employed in separating copper, and the copper costs more to refine than when no iron or manganese is present. As long as there is sufficient persalt of iron in the liquid, no hydrogen is evolved at the cathode. With a copper-depositing solution containing much salt of iron, the difference of potential of plates of pure copper of a single vat has been found by experiment to be ·22 volt, with an anode of black copper ·25 volt, and with one of copper pyrites ·5 volt, and when the solution was deficient in free acid, it was ·35 volt with black copper, and ·75 volt with copper pyrites (Kiliani, *Engineering*, Vol. XL., 1885, p. 306).

Effect of Impurities of the Liquid upon Purity of the Deposit. The electrolyte is always less impure than the anode, because various of the impurities of the latter are either loosened by corrosion of the surrounding metal, and separate and fall to the bottom unchanged; or they are separated from their compounds by chemical or electro-chemical decomposition and subside; or they are converted by chemical action into insoluble compounds, which precipitate.

The more impure the anode, the less pure usually is the electrolyte. In addition to the proper constituents of the liquid, viz., blue vitriol, sulphuric acid, and water, there may be present in a dissolved state the sulphates of iron, zinc, manganese, cadmium, cobalt, aluminium, magnesium, calcium, potassium, and sodium, basic sulphates of antimony, tellurium, bismuth, and tin, and arsenious or arsenic acid.

By far the largest in amount of these dissolved impurities is the sulphate of iron; but the most objectionable ones are the compounds of arsenic, antimony, and bismuth, because they are the most likely to yield their metals at the cathode, and thus affect the purity and quality of the deposited copper.

During the process of deposition the electrolyte continually becomes more impregnated with impurities, especially with iron, and, in much less degrees, also with zinc, manganese, cobalt, nickel, tin, arsenic, antimony, bismuth, aluminium, calcium (within small limits), magnesium, potassium, and sodium, and gradually poorer in free acid, and, sooner or later, requires to be purified.

Influence of Impurities of the Liquid upon the Current.—The greater the number of impurities in the electrolyte, the greater the risk of waste of electric energy. All ordinary sulphate of copper solution used in the electrolytic refining of copper contains, after a time, a greater or less proportion of dissolved ferrous sulphate, and this substance gradually combines with the oxygen of the air and becomes persalt. In such a mixture there is liable to occur a considerable waste of current and deficiency of deposited copper—1st, because much of the electric energy is wasted in deoxidising the persalt at the cathode; and 2nd, because a solution of persalt of iron corrodes and dissolves copper; the free acid therefore decreases, and the liquid acquires greater specific gravity. The presence of green vitriol, however, prevents polarisation at the anode, because it absorbs oxygen.

In a solution of green vitriol partly oxidised by the air, and being suitably electrolysed with platinum electrodes, a mixture of iron and hydrogen is deposited at the cathode, and persalt is

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formed at the anode; and, owing to absorption of oxygen from the air, the proportion of persalt increases.

Purity of the Deposited Copper.—It is a mistake to suppose that electro-deposited copper must be pure; if it has been deposited rapidly from an impure solution it may be very impure. The purest electro-deposited copper is apt to contain traces of tellurium, bismuth, and silver. These have been detected by photographing the spectrum of the copper. The presence of the first two of these would be due either to the density of the current at the cathode being too great, the liquid insufficiently stirred, or the proportion of copper being too small, or to all these causes combined; but most likely to a combination of the first and second. The presence of silver may be due to absence of soluble chlorides, or to sediment falling from the anode.

Of all the various circumstances already described which tend to produce purity of the copper, the most important are:—1. Absence *in solution* of all the metals which are the most readily deposited with it: these are silver, bismuth, antimony, arsenic, and tin; 2, using a sufficiently moderate density of current at the cathode; 3, keeping the solution perfectly clear and well circulated; and 4, not allowing any of the mud from the anode to touch the cathodes. All other conditions being alike, the most slowly deposited metal is the most pure.

There is usually not much risk of depositing any other metal than copper (and silver or bismuth if in solution) under the ordinary conditions of working when the density of current does not exceed 5 amperes per square foot, or the rate of deposition is not more than 70·7 grains per square foot per hour, and the increase of thickness is not greater than 1·07 millimetres, or ·04 of an inch per week of 156 hours. At Stolberg, with an impure solution, and a density of current of 1·482 ampere per square foot, the purity of the deposited copper is stated to be "99·92 and 99·95 per cent. in two analyses." One source of impurity is fine powder from the anodes diffused in the liquid.

The difference of purity of the deposit obtained with different qualities of anodes depends very little upon the electric conductivity of the metal, because with every quality of copper the large mass of the anode has vastly less resistance than the electrolyte; but it depends very greatly upon the kind of impurities. If the impurities are soluble and readily deposited along with the copper, it is then necessary to reduce the speed of deposition, but this greatly increases the cost. According to a German writer (Dingler's *Polytechnisches Journal*, Vol. CCLV., p. 531), the copper deposited at the Oker refinery is extremely perfect, whilst that of some English electrolytic refineries is less so; probably the latter had been too rapidly deposited. Some samples of American-deposited copper have also been found to be impure. A minute proportion of antimony or bismuth destroys the good qualities of copper.

Cost of Electrolytic Refining.—The cost of refining copper by electrolysis varies with the magnitude of the installation, and depends essentially upon the expense of motive-power, and of interest upon invested capital; also largely upon the degree of "commercial efficiency" of the dynamo, and upon the kind and amount of impurities in the crude metal, which are continually varying, because the composition of each batch of unrefined copper differs. The larger the proportion of foreign metals which are easily deposited with the copper, and the purer the refined copper required, the greater the cost of the process, because it must be conducted more slowly. The cost when anodes composed of the unreduced sulphides of copper and iron are employed instead of metallic copper, as in "Marchese's process," is considerably different.

Where motive-power or fuel is cheap, advantage is taken of the circumstance to economise the expenditure upon vats and copper, by using it more freely. At Casarza, where water-power is cheap, the proportion of copper deposited is 1·4lb. per horse-power per hour; at Pembrey, where coal is cheap, it is 2·6lb.; but at Hamburg, where motive-power and fuel are dear, it is 6·87lb. The amount of electric energy and of horse-power consumed in depositing the same weight of copper differs in nearly every electrolytic refinery. Where coal is cheap, and the process is conducted on a large scale, with a good steam engine, at least 110 indicated horse-power is obtained during one week by the consumption of 50 tons of coal, and with good dynamos will deposit 20 tons of copper per week, at a cost of £20. The interest upon capital invested in plant, &c., during the same period will amount to about a similar sum. Or, if we reckon the cost of one mechanical horse power at one penny per hour, the cost of such power for electrolytic refining of copper is about one farthing per pound of that metal refined. Difference of potential required to overcome resistance and polarisation is also an element in calculating the cost of depositing a given amount of copper, because double the electromotive force expended costs quite double the money.

The chief elements of cost are:—1. Interest upon capital expended upon copper, electrolyte, vats, steam-engine, boiler, dynamo, and other plant. 2. Fuel, water, and oil for the engine. 3. Rent and taxes. 4. Labour. 5. Depreciation of steam-engine, boiler, dynamos, vats, &c. 6. Incidental expenses.

The total stock of copper required in order to refine a given amount of that metal per day or week varies in different works. In each refinery, besides the amount of copper in the vats, there is at least an equal quantity in the form of main conductors, raw copper for making anodes, new anodes ready for immersion, and residues of old anodes, also the stock of refined copper. The value of the stock of copper alone in one of the installations at Hamburg has been estimated at "£8,000." Practically, to refine 30 tons a week of ordinary "Chili bars," with a current density of 8 or 10 amperes per square foot, requires a total stock of about 400 tons of copper, which, at £50 a ton, costs £20,000, to which we must add about £10,000 for plant and premises.

A number of workmen are necessary, probably about twenty, working day and night, when depositing thirty tons of copper per week, to manipulate the electrodes, examine the vats, and attend to the steam-engine and dynamo, melt and cast anodes, wash dirty ones, &c. A chemical analyst is also employed to analyse the copper and the electrolyte. As stoppages in the process do not often occur, they are not a large element of expense; there is, however, the cost of occasionally emptying the vats, evaporating and purifying the solution, collecting and treating the mud, &c.

The cost of one of the latest forms of dynamo for electrolytic refining of copper by Messrs. Siemens and Halske, viz., their "H C^{II}" type, constructed to give 1,000 amperes at a difference of potential of 60 volts, was "£420," and that of a 50-unit one, by Messrs. Chamberlain and Hookham, giving 500 amperes at 100 volts, about £400. With large vats, and large currents of low electromotive force, the cost for the same rate of deposition is less, but that of the dynamo and conductors is greater than with small vats and small currents of higher electromotive force. A vat containing one cubic metre costs "about 130fr.," and one of three cubic metres "double that sum." The vats at Biache cost "350fr. each." One cubic metre of the ordinary copper solution costs "about 70fr."

The total cost of M. Hilarion Roux's installation at Marseilles, including the baths, dynamo, and steam-engine to refine "250 kilogrammes per day" (=89½ tons yearly), is stated to have been "£1,000," and the amount of invested capital "£5,000 to £6,000." The "Società Anonima Italiana di Miniere di Rame e di Elettro-Metallurgia," in Genoa, whose works are at Casarza, was established with a capital of 4·8 million marks (=£240,000) (Dingler's *Polytechnisches Journal*, 1885, Vol. CCLV., p. 201).

It might be supposed that the silver and gold recovered constitutes a considerable profit, but all this has to be paid for extra in purchasing the crude metal.

In consequence of the numerous circumstances which affect the cost, an approximately satisfactory estimate of the total amount of capital required to be invested in establishing an electrolytic refinery to deposit a given amount of copper daily, can only be arrived at by means of a knowledge of all the essential particulars in the given case.

Recapitulation.—In establishing an electrolytic copper refinery, the chief points usually require to be settled in the following order:—1st. The amount of copper to be deposited per week. 2nd. Amount of mechanical power required and the kind of motor. 3rd. Degree of purity of the solution and of the crude metal. 4th. Rate of deposition per square foot of cathode

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surface per week. 5th. Total amount of cathode surface necessary. 6th. Total number of vats in series. 7th. Magnitude of each vat. 8th. Electromotive force and strength of current necessary. 9th. Kind of dynamo. 10th. Magnitude of the main conductors. There are, of course, other important points to be first considered, such as the most suitable locality for cheap motive-power, cheap conveyance, &c., but those do not come within the intended scope of this article.

ON THE DETERMINATION OF THE WORK DONE UPON THE CORES OF IRON IN ELECTRICAL APPARATUS SUBJECT TO ALTERNATING CURRENTS.

BY T. H. BLAKESLEY, M.A., M. INST. C.E.

When the case is one of a transformer the problem may be solved by the employment of three dynamometers in the way I have already* pointed out; but in that of an electro-magnet, where we have only one coil to deal with, the problem still admits of solution if we further employ a condenser of determined capacity, and have a knowledge of the period, by means of some speed indicator. The plan is as follows:—

Arrangement.—Having the machine and magnet in series, insert the three dynamometers in series immediately at one terminal of the electro-magnet, and place one pole of the condenser to the other terminal, and the second pole of the condenser to that point of the middle dynamometer where its two coils join.

Observations.—Obtain good simultaneous readings of the three dynamometers, and if necessary of the speed indicator.

Calculations.—Let α_1, α_2, α_3 be the angles, read upon the instrument (1) in the generating section (2) in the electro-magnet section (3) which has its coils divided.

Let the reducing formulæ for the three instruments be

$$\left.\begin{aligned}(\text{Current})^2 &= k_1\,\theta\\ \text{,,} &= k_2\,\theta\\ \text{,,} &= k_3\,\theta\end{aligned}\right\} \text{ respectively.}$$

Let C be the capacity of the condenser.

R ,, ,, resistance of the electro-magnet section of the circuit.

Then the entire power at work beyond the poles—*i.e.*, the heating of the wire, the heating of the core by induced currents, and the heating of the core due to hysteresis—is expressed by the simple formula:

$$\frac{T}{\pi C}\sqrt{k_1\alpha_1 k_2\alpha_2 - k_3{}^2\alpha_3{}^2}$$

T being the semi-period.

The expression itself is independent of the resistance; but if we desire to know the power heating the core, we must deduct from the above result the power heating the wire—viz., $k_2\alpha_2$ R.

The difference between these two quantities also happens to be proportional to the tangent of the magnetic lag, another proof of the invariable concurrency of lag and loss of power.

* *The Electrician*, Vol. XXI., p. 88.

Electric Light for Diving Apparatus.—Some improvements in diving apparatus have been effected by M. Albert Marcelhacy, a French engineer. Instead of the heavy electric hand lamp hitherto used by divers, he affixes a light but powerful glow lamp on the top of the helmet, so that the diver's hands are both at all times free for work. The lamp is connected by a conductor with a battery either on shore or in a vessel above, as the case may be. These improvements, which have been adopted in the French navy, are being introduced in this country by Mr. R. Applegarth, of 11, Queen Victoria-street, London.

THE COEFFICIENT OF MUTUAL INDUCTION OF TWO PARALLEL WIRES.*

BY DR. CARY T. HUTCHINSON.

Consider two wires running parallel for a distance, l, and at a distance, d, apart. Then, neglecting the effect of the return circuits, it can be shown that the coefficient of mutual induction, M, is proportional to

$$M \propto l\left[\log_e \frac{2l}{d} - 1\right]$$

or

$$M \propto l\left[2.3\log_{10}\frac{2l}{d} - 1\right] \quad \ldots\ldots (1)$$

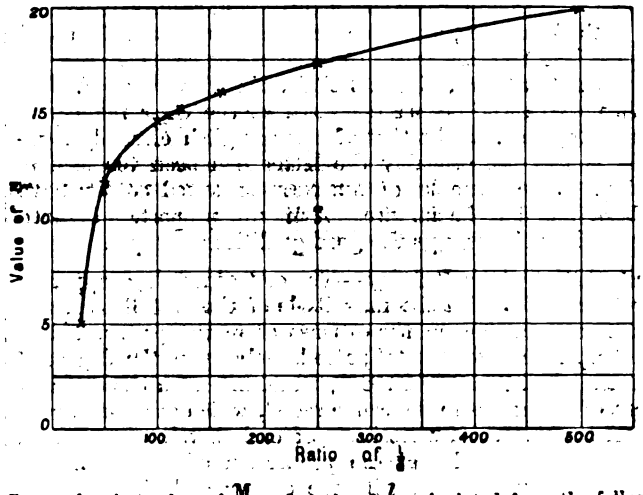
provided d/l is a very small quantity.

This expression would represent, in the simplest conceivable case, the dependence of the disturbing effect of a telegraph or trolley line upon the geometrical constants of the circuits. In applying it to actual cases, the effect of the various telephone wires upon each other and the effect of electrostatic induction are the most important factors neglected; the latter, indeed, has been shown experimentally to be the dominant factor in some cases; yet it is probable that in the actual case the general form of the expression for M would be similar to the above.

A simple consideration shows this to be true. The coefficient of mutual induction is proportional to the number of lines of force linked with both circuits; if then the distance of parallelism and the distance apart be increased in the same ratio, the proportion of lines linked to total lines in one circuit will be approximately the same; but the absolute number of lines, upon which M depends, will be doubled. In no case does the effect vary inversely as the distance apart.

The equation shows that the effect varies directly as the distance of parallelism only when the ratio of this distance to the distance apart is kept constant; that is, if the distance of parallelism is doubled, the distance apart being kept constant, the effect will be considerably more than doubled; but if the distance apart be doubled at the same time, then the effect, always to the degree of approximation mentioned, will be doubled.

The following numerical Table shows all this clearly; it is calculated from (1) the numbers given for M being only proportional, not absolute values, the numbers given in the last column are obtained by dividing by l, and their connection with the corresponding values in the fourth column is shewn in the subjoined curve, which we have added.



Curve showing value of $\frac{M}{l}$ and ratio of $\frac{l}{d}$, calculated from the following

TABLE.

No.	l (feet).	d (feet).	$\frac{l}{d}$	M	$\frac{M}{l}$
1	10,000	20	500	200	20
2	5,000	20	250	88	17·6
3	2,500	20	125	38	15·2
4	1,000	20	50	12	12
5	500	20	25	5	5
6	5,000	10	500	100	20
7	5,000	20	250	88	17·6
8	5,000	30	167	81	16·2
9	5,000	40	125	77	15·4
10	5,000	50	100	73	14·6
11	5,000	100	50	61	12·2

* Abstract from the *Electrical Engineer* of New York.

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Comparing Nos. 1 and 5 shows that increasing the distance 20-fold increases the effect 40-fold ; Nos. 2 and 5 show that increasing the distance 10-fold increases the effect 17-fold, when the distance apart is constant. When the length of parallelism is constant, Nos. 6 and 11 show that increasing the distance apart 10-fold diminishes the effect only to ·61, and not to ·1. This makes the case for telephones very bad, and shows the necessity for metallic circuits—for the telephones, of course.

THE ELECTRO-MAGNET.*

BY PROF. SILVANUS P. THOMPSON.

(Continued from page 719.)

In order to study this question of leakage, and the relation of leakage to pull, still more incisively, I devised some time ago a small experiment, with which a group of my students at the Technical College have been diligently experimenting. Here (Fig. 43) is a horse-shoe electro-magnet. The core is of soft wrought iron, wound with a known number of turns of wire. It is provided with an armature. We have also wound on three little exploring coils, each consisting of five turns of wire, only one, C, right down at the bottom, on the bend ; another, B, right round the pole, close up to the armature ; and a third, A, around the middle of the armature. The object of these is to ascertain how much of the magnetism which was created in the core by magnetising power of these coils ever got into the armature. If the armature is at a considerable distance away, there is naturally a great deal of leakage.

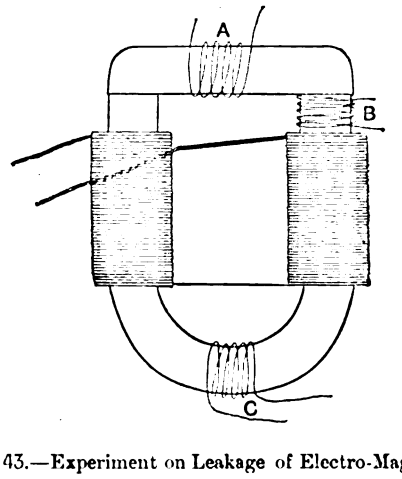

FIG. 43.—Experiment on Leakage of Electro-Magnet.

The coil C, around the bend at the bottom is to catch all the magnetic lines that go through the iron ; the coil B, at the poles, is to catch all that have not leaked outside before the magnetism has crossed the joint ; while the coil A, right around the middle of the armature, catches all the lines that actually pass into the armature and pull at it. We measure by means of the ballistic galvanometer and these three exploring coils how much magnetism gets into the armature at different distances, and are able thus to determine the leakage and compare these amounts with the calculations made, and with the attractions at different distances. The amount of magnetism that gets into the armature does not go by a law of inverse squares, I can assure you, but by quite other laws. It goes by laws which can only be expressed as particular cases of the law of the magnetic circuit. The most important element of the calculations, indeed, in many cases is the amount of percentage of leakage that must be allowed for. Of the magnitude of this matter you will get a very good idea by the result of these experiments following.

The iron core is 13 millimetres in diameter, and the coil consists of 178 turns. The first swing of the galvanometer when the current was suddenly turned on or off measures the number of magnetic lines thereby sent through, or withdrawn from, the exploring coil that is at the time joined to the galvanometer. The currents used varied from 0·7 of an ampere to 5·7 amperes. Six sets of experiments were made, with the armature at different distances. The numerical results are given in the following tables :—

Table I.—*With Weak Current* (0·7 *Amperes*).

—	A	B	C
In contact	12,506	13,870	14,190
Armature distance, 1mm.	1,552	2,163	3,786
" " 2mm.	1,149	1,487	2,839
" " 5mm.	1,014	1,081	2,028
" " 10mm.	676	1,014	1,690
Removed	—	675	1,352

Table II.—*Stronger Current* (1·7 *Amperes*).

—	A	B	C
In contact	18,240	19,590	20,283
Armature distance, 1mm.	2,570	3,381	5,408
" " 2mm.	2,266	2,839	5,073
" " 5mm.	1,352	2,299	5,949
" " 10mm.	811	1,352	3,381
Removed	—	1,308	3,041

Table III.—*Still Stronger Current* (3·7 *Amperes*).

—	A	B	C
In contact	20,940	22,280	22,960
Armature distance, 1mm.	5,610	7,568	11,831
" " 2mm.	4,597	6,722	9,802
" " 5mm.	2,569	3,245	7,436
" " 10mm.	1,149	2,704	7,098
Removed	—	2,366	6,427

Table IV.—*Strongest Current* (5·7 *Amperes*).

—	A	B	C
In contact	21,980	23,660	24,040
Armature distance, 1mm.	8,110	10,810	17,220
" " 2mm.	5,611	8,464	15,856
" " 5mm.	4,056	5,273	12,627
" " 10mm.	2,029	4,057	10,142
Removed	—	3,531	9,795

These numbers may be looked upon as a kind of numerical statement of the facts roughly depicted in Figs. 31 to 34. The numbers themselves, so far as they relate to the measurements made (1) in contact, (2) with gaps of one millimetre breadth, are plotted out on Fig. 44; there being three curves, A, B, and C, for the measurements made when the armature was in contact, and three others, A_1, B_1, C_1, made at the one millimetre distance. A dotted line gives the plotting of the numbers for the coil C, with different currents, when the armature was removed.

On examining the numbers in detail, we observe that the largest number of magnetic lines forced round the bend of the iron core, through the coil C, was 24,040 (the cross-section being a little over 1 square centimetre), which was when the armature was in contact. When the armature was away, the same magnetising power only evoked 9,795 lines. Further, of those 24,040, 23,660 (or 98½ per cent.) came up through the polar surfaces of contact, and of those again 21,980 (or 92½ per cent. of the whole number) passed through the armature. There was leakage, then, even when the armature was in contact, but it amounted to only 7½ per cent. Now, when the armature was moved but 1 millimetre (*i.e.*, $\frac{1}{25}$th of an inch) away, the presence of the air gaps had this great effect, that the total magnetic flux was at once choked down from 24,040 to 17,220. Of that number only 10,810 (or 61 per cent.) reached the polar surfaces, and only 8,110 (or 47 per cent. of the total number) succeeded in going through the armature. The leakage in this case was 53 per cent. With a 2 millimetre gap, the leakage was 65 per cent. when the strongest current was used. It was 68 per cent. with a 5 millimetre gap, and 80 per cent. with a 10-millimetre gap. It will further be noticed that whilst a current of 0·7 ampere sufficed to send 12,506 lines through the armature when it was in contact, a current eight times as strong could only succeed in sending 8,110 lines when the armature was distant by a single millimetre.

Such an enormous diminution in the magnetic flux through the armature consequent upon the increased reluctance and increased leakage occasioned by the presence of the air-gaps, proves how great is the reluctance offered by air, and how essential it is to have some practical rules for calculating reluctances and estimating leakages to guide us in designing electro-magnets to do any given duty.

* A series of four Cantor Lectures delivered before the Society of Arts, January—February, 1890.

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The calculation of magnetic reluctances of definite portions of a given material are now comparatively easy, and, thanks to the formulæ of Prof. Forbes, it is now possible in certain cases to estimate leakages. Of these methods of calculation an abstract will be given in the appendix to this lecture. I have, however, found Forbes's rules, which were intended to aid the design of dynamo-machines, not very convenient for the common cases of electro-magnets, and have, therefore, cast about to discover some more apposite mode of calculation. To predetermine the probable percentage of leakage one must first distinguish between those magnetic lines which go usefully through the armature (and help to pull it) and those which go astray through the surrounding air and are wasted so far as any pull is concerned. Having set up this distinction, one then needs to know the relative magnetic conductance, or *permeance*, along the path of the useful lines and that along the innumerable paths of the wasted lines of the stray field. For (as every electrician accustomed to the problem of shunt circuits will recognise) the quantity of lines that go respectively along the useful and wasteful paths will be directly proportional to the conductances (or permeances) along those paths, or will be inversely proportional to the respective resistances along those paths. It is customary in electro-magnetic calculations to employ a certain coefficient of allowance for leakage, the symbol for which is v, such that when we know the number of magnetic lines that are wanted to go through the armature we must allow for v times as many in the magnet core. Now, if u represents permanence along the useful path, and w the permanence of all the waste paths along the stray field, the total flux will be to the useful flux as $u+w$ is to u. Hence the coefficient of allowance for leakage

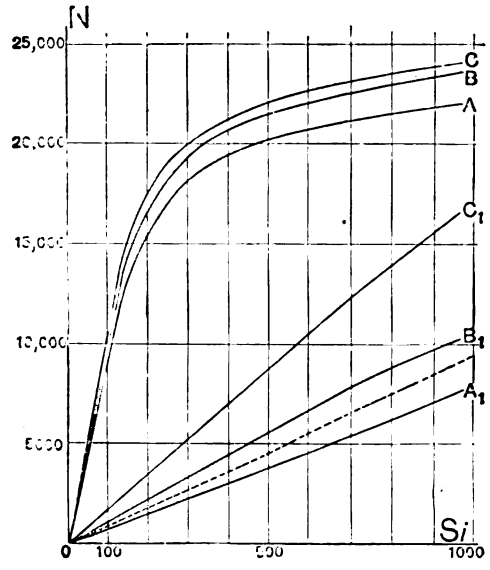

FIG. 44.—Curves of Magnetisation Plotted from Preceding.

v, is equal to $u+w$ divided by u. The only real difficulty is to calculate u and w. In general u is easily calculated; it is the reciprocal of the sum of all the magnetic reluctances along the useful path from pole to pole. In the case of the electro-magnet used in the experiments last described, the magnetic reluctances along the useful path are three in number, that of the iron of the armature, and those of the two air gaps. The following formula is applicable:—

$$\text{reluctance} = \frac{l_1}{A_1 \mu_1} + \frac{2 l_2}{A_2},$$

if the data are specified in centimetre measure; the suffixes 1 and 2 relating respectively to the iron and to the air. If the data are specified in inch measures the formula becomes

$$\text{reluctance} = 0{\cdot}3132 \left\{ \frac{l''_1}{A''_1 \mu_1} + \frac{2 l''_2}{A''_2} \right\}$$

But it is not so easy to calculate the reluctance (or its reciprocal, the permeance) for the waste lines of the stray field, because the paths of the magnetic lines spread out so extraordinarily and bend round in curves from pole to pole.

Fig. 45 gives a very fair representation of the spreading of the lines of the stray field that leaks across between the two limbs of a horseshoe electro-magnet made of round iron. And for square iron the flow is much the same, except that it is concentrated a little by the corners of the metal. Forbes's rules do not help us here. We want a new mode of considering the subject.

The problems of flow, whether of heat, electricity, or of magnetism, in space of three dimensions, are not among the most easy of geometrical exercises. However, some of them have been worked out, and may be made applicable to our present need. Consider, for example, the electrical problem of finding the resistance which an indefinitely extended liquid (say a solution of sulphate of copper of given density) offers when acting as a conductor of electric currents flowing across between two indefinitely long parallel cylinders of copper. Fig. 45 may be regarded as representing a transverse section of such an arrangement, the sweeping curves representing lines of flow of current. In a simple case like this it is possible to find an accurate expression for the resistance (or for the conductance) of a layer or stratum of unit thickness. It depends on the diameters of the cylinders, on their distance apart, and on the specific conductivity of the medium. It is not by any means proportional to the distance between them, being, in fact, almost independent of the distance, if that is greater than twenty times the perimeter of either cylinder. Neither is it even approximately proportional to the perimeter of the cylinders except in those cases when the shortest distance between them is less than a tenth part of the perimeter of either. The resistance, for unit length of the cylinders, is, in fact, calculated out by the rather complex formula:—

$$R = \frac{1}{\pi \mu} \text{ log. nat. } h;$$

Where

$$h = \frac{2a}{b + 2a - \sqrt{b^2 + 4ab}};$$

the symbol a standing for the radius of the cylinder; b for the shortest distance separating them; μ for the permeability, or in the electric case the specific conductivity of the medium.

Now, I happened to notice, as a matter that greatly simplifies the calculation, that if we confine our attention to a transverse layer of the medium of given thickness, the resistance between the

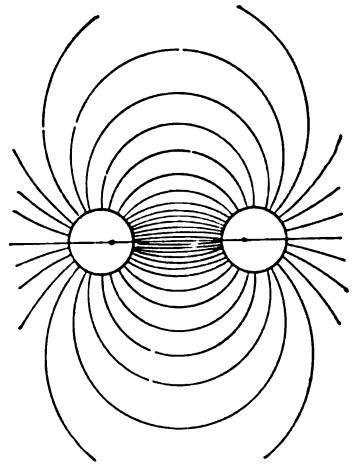

FIG. 45.—Curves of Flow of Magnetic Lines in Air from one Cylindrical Pole to another.

two bits of the cylinders in that layer depends on the ratio of the shortest distance separating them to their periphery, and is independent of the absolute size of the system. If you have the two cylinders an inch round, and an inch between them, then the resistance of the slab of medium (of given thickness) in which they lie will be the same as if they were a foot round and a foot apart. Now that simplifies matters very much, and thanks to my friend and former chief assistant, Dr. R. Mullineux Walmsley, who devoted himself to this troublesome calculation, I am able to give you, in tabular form, the magnetic resistance within the limits of proportion that are likely to occur.

The numbers from columns 1 and 2 of Table VII. are plotted out graphically in Fig. 46, for more convenient reference. As an example of the use of the Table we will take the following:—

EXAMPLE.—Find the maenetic reluctance and permeance between two parallel iron cores of 1in. diameter and 9in. long, the least distance between them being $2\frac{3}{8}$in. Here $b = 2{\cdot}375$; $p = 3{\cdot}1416\, b \div p = 0{\cdot}756$. Reference to the table shows (by interpolation) that the reluctance and permeance for unit thickness of slab are respectively 0·183 and 5·336. For 9in. thickness they will therefore be 0·021 and 48·02 respectively.

When the permeance across between the two limbs is thus approximately calculable, the waste flux across the space is estimated by multiplying the permeance so found by the *average* value of the difference of magnetic potential between the two limbs. And this, if the yoke which unites the limbs at the lower end is of good solid iron, and if the parallel cores offer little magnetic reluctance as compared with the reluctance of the useful paths, or of that of the stray field, may be simply taken as half the ampere-turns (or if centimetre measures are used multiply by 1·2566).

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TABLE VIII.—*Magnetic Reluctance of Air between Two Parallel Cylindrical Limbs of Iron.*

$\frac{b}{p}$ Ratio of least distance apart to perimeter.	Magnetic reluctance in C.G.S. units = the magneto-motive force ÷ total magnetic flux.		Magnetic reluctance in inch units = the ampere-turns ÷ the total magnetic flux. Slab = 1in. thick.	
	Reluctance.	Permeance.	Reluctance.	Permeance.
0·1	0·2461	4·063	0·0771	12·968
0·2	0·3404	2·938	0·1066	9·377
0·3	0·4084	2·449	0·1280	7·815
0·4	0·4623	2·161	0·1450	6·897
0·5	0·5084	1·967	0·1593	6·278
0·6	0·5479	1·825	0·1717	5·825
0·8	0·6140	1·629	0·1924	5·198
1·0	0·6681	1·497	0·2093	4·777
1·2	0·7144	1·400	0·2238	4·571
1·4	0·7550	1·324	0·2365	4·228
1·6	0·7903	1·265	0·2476	4·039
1·8	0·8220	1·217	0·2575	3·883
2·0	0·8511	1·202	6·2667	3·750
4·0	1·0500	0·952	0·3290	3·040
6·0	1·1710	0·854	0·3669	2·726
8·0	1·2624	0·792	0·3955	2·528
10·0	1·3250	0·755	6·4151	2·409

NOTE.—In the above table, unit-length of cylinders is assumed (one centimetre in columns two and three ; 1in. in columns four and five) ; the flow of magnetic lines being reckoned as in a slab of infinite extent, and of unit thickness. Symbols : p = perimenter of cylinder ; b = shortest distance between cylinders. In columns two and three the unit reluctance is that of a centimetre cube of air. In columns four and five the unit reluctance is so chosen (as in the rest of these lectures wherever such measures are used) that the reduction of ampere-turns to magneto-motive force by multiplying by $4\pi \div 10$ is avoided. This will make the reluctance of the inch cube of air equal to $10 \div 4\pi \div 2{\cdot}54 = 0{\cdot}3132$; and its permeance as 3·1931.

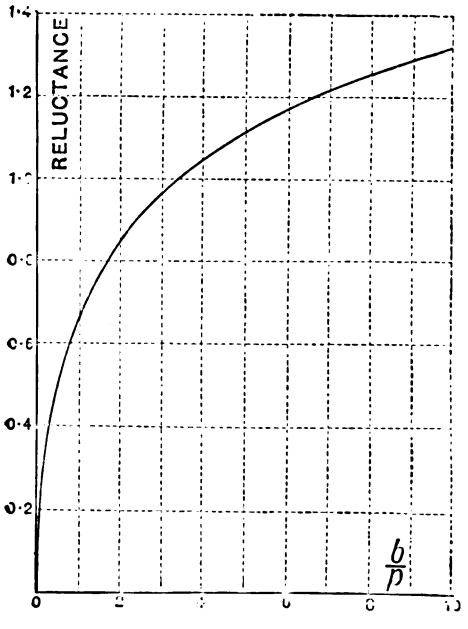

FIG. 46.—Diagram of Leakage Reluctances.

The method here employed in estimating the reluctance of the waste field is, of course, only an approximation ; for it assumes that the leakage takes place only in the planes of the slabs considered. As a matter of fact, there is always some leakage out of the planes of the slabs. The real reluctance is always, therefore, somewhat less, and the real permeance somewhat greater than that calculated from Table VIII.

For the electro-magnets used in ordinary telegraph instruments the ratio of b to p is not usually very different from unity, so that for them the permeance across from limb to limb per inch length of core is not very far from 5·0, or nearly twice the permeance of an inch cube of air.

We are now in a position to see the reason for a curious statement of Count Du Moncel which for long puzzled me. He states that he found, using distance apart of one millimetre, that the attraction of a two-pole electro-magnet for its armature was less when the armature was presented laterally than when it was placed in front of the pole-ends, in the ratio of 19 to 31. He does not specify in the passsage referred to what was the shape of either the armature or the cores. If we assume that he was referring to an electro-magnet with cores of the usual sort—round iron with flat ends, presumably like Fig. 11—then it is evident that the air gaps, when the armature is presented sideways to the magnet, are really greater than when the armature is presented in the usual way, owing to the cylindric curvature of the core. So, if at equal measured distance the reluctance in the circuit is greater, the magnetic flux will be less and the pull less.

It ought also now to be evident why an armature made of iron of a flat rectangular section, though when in contact it sticks on tighter edgeways, is at a distance attracted more powerfully if presented flatways. The gaps, when it is presented flatways (at an equal least distance apart) offer a lesser magnetic reluctance.

Another obscure point also becomes explainable, namely, the observations by Lenz, Barlow, and others, that the greatest amount of magnetism which could be imparted to long iron bars by a given circulation of electric current was (nearly) proportional, not to the cross-sectional area of the iron, but to its surface. The explanation is this. Their magnetic circuit was a bad one, consisting of a straight rod of iron and of a return path through air. Their magnetising force was being in reality expended not so much on driving magnetic lines through iron (which is readily permeable); but on driving the magnetic lines through air (which is, as we know, much less permeable), and the reluctance of the return paths through the air is—when the distance from one to the other of the exposed end parts of the bar is great compared with its periphery—very nearly proportional to that periphery, that is to say, to the exposed surface.

Another opinion on the same topic was that of Prof. Müller, who laid down the law that for iron bars of equal length, and excited by same magnetising power, the amount of magnetism was proportional to the square root of the periphery. A vast amount of industrious scientific effort has been expended by Dub, Hankel, Von Feilitzsch, and others on the attempt to verify this "law." Not one of these experimenters seems to have had the faintest suspicion that the real thing which determined the amount of magnetic flow was not the iron but the reluctance of the return-path through air. Von Feilitzsch plotted out the accompanying curves (Fig. 47), from which he drew the inference that the law of the square root of the periphery was established. The very straightness of these curves shows that in no case had the iron become so much magnetised as to show the bend that indicates approaching saturation. Air, not iron, was offering the main part of the resistance

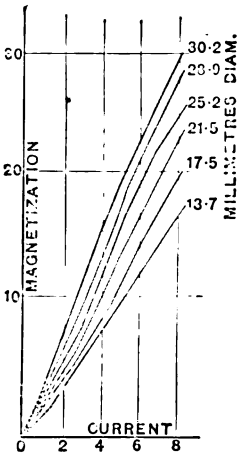

FIG. 47.—Von Feilitzsch's Curves of Magnetisation of Rods of Various Diameters.

to magnetisation in the whole of these experiments. I draw from the very same curves the conclusion that the magnetisation is not proportional to the square root of the periphery, but is more nearly proportional to the periphery itself ; indeed, the angles at which the different curves belonging to the different peripheries rise show that the amount of magnetism is very nearly as the surface. Observe here we are not dealing with a closed magnetic circuit where section comes into account ; we are dealing with a bar in which the magnetism can only get from one end to the other by leaking all round into the air. If, therefore, the reluctance of the air path from one end of the bar to the other is proportional to the surface, we should get some curves very like these ; and that is exactly what happens. If you have a solid, of a certain given geometrical form, standing out in the middle of space, the conductance which the space around it (or rather the medium filling that space) offers to the magnetic lines flowing through it, is practically proportional to the surface. It is distinctly so for similar geometrical solids, when they are relatively small as compared with the distance between them. Electricians know that the resist-

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ance of the liquid between two small spheres, or two small discs of copper immersed in a large bath of sulphate of copper, is practically independent of the distance between them, provided they are not within 10 diameters, or so, of one another. In the case of a long bar we may treat the distance between the protruding ends as sufficiently great to make an approximation of this law hold good. Von Feilitzsch's bars were, however, not so long that the average value of the length of path from one end surface to the other end surface, along the magnetic lines, was infinitely great as compared with the periphery. Hence the departure from exact proportionality to the surface. His bars were 9·1 centimetres long, and the peripheries of the six were respectively 94·9, 90·7, 79·2, 67·6, 54·9, and 42·9 millimetres.

It has long been a favourite idea with telegraph engineers that a long-legged electro-magnet in some way possessed a greater "projective" power than a short-legged one; that, in brief, a long-legged magnet could attract an armature at a greater distance from its poles than could a short-legged one made with iron cores of the same section. The reason is not far to seek. To project or drive the magnetic lines across a wide intervening air-gap requires a large magnetising force on account of the great reluctance, and the great leakage in such cases. And the great magnetising force cannot be got with short cores, because there is not, with short cores, a sufficient length of iron to receive all the turns of wire that are in such a case essential. The long-leg is wanted simply to carry the wire necessary to provide the requisite circulation of current.

We now see how, in designing electro-magnets, the length of the iron core is really determined; it must be long enough to allow of the winding upon it of the wire which, without overheating, will carry the ampere-turns of exciting current which will suffice to force the requisite number of magnetic lines (allowing for leakage) across the reluctances in the useful path. We shall come back to this matter after we have settled the mode of calculating the quantity of wire that is required.

Being now in a position to calculate the additional magnetising power required for forcing magnetic lines across an air gap, we are prepared to discuss a matter that has been so far neglected, namely, the effect on the reluctance of the magnetic circuit, of joints in the iron. Horse-shoe electro-magnets are not always made of one piece of iron bent round. They are often made, like Fig. 11 of two straight cores shouldered and screwed, or riveted into a yoke. It is a matter purely for experiment to determine how far a transverse plane of section across the iron obstructs the flow of magnetic lines. Armatures, when in contact with the cores, are never in perfect contact, otherwise they would cohere without the application of any magnetising force; they are only in imperfect contact, and the joint offers a considerable magnetic reluctance. This matter has been examined by Prof. J. J. Thomson and Mr. Newell, in the Cambridge Philosophical Society's Proceedings, in 1887; and recently more fully by Prof. Ewing, whose researches are published in the *Philosophical Magazine* for September, 1888. Ewing not only tried the effect of cutting and of facing up with true plane surfaces, but used different magnetising forces, and also applied various external pressures to the joint. For our present purpose we need not enter into the questions of external pressures, but will summarise the results which Ewing found when his bar of wrought iron was cut across by section planes, first into two pieces, then into four, then into eight. The apparent permeability of the bar was reduced at every cut.

Table IX.—*Effect of Joints in Wrought Iron Bar (not compressed).*

H	B				Mean thickness of equivalent air-space for one cut.		Thickness of iron of equivalent reluctance per cut.	
	Solid.	Cut in two.	In Four.	In Eight	Centimetres.	Inches.	Centimetres.	Inches.
7·5	8,500	6,900	4,809	2,600	0·0036	0·0014	4	1·57
15	13,400	11,550	8,900	5,550	0·0030	0·0012	2·53	1·00
30	15,350	14,550	12,940	9,800	0·0020	0·0008	1·10	0·433
50	16,400	15,950	15,000	13,300	0·0013	0·0005	0·43	0·169
70	17,100	16,840	16,120	15,200	0·0009	0·0004	0·22	0·087

Suppose we are working with the magnetisation of our iron pushed to about 16,000 lines to the square centimetre (*i.e.*, about 150lb. per square inch, traction), requiring a magnetising force of about H = 50; then, referring to the Table, we see that each joint across the iron offers as much reluctance as would an air-gap 0·0005 of an inch in thickness, or adds as much reluctance as if an additional layer of iron about one-sixth of an inch thick had been added. With small magnetising forces the effect of having a cut across the iron with a good surface on it is about the same as though you had introduced a layer of air one six-hundredth of an inch thick, or as though you had added to the iron circuit about one inch of extra length. With large magnetising forces, however, this disappears, probably because of the attraction of the two surfaces across that cut. The stress in the magnetic circuit, with high magnetic forces running up to 15,000 or 20,000 lines to the square centimetre, will of itself put on a pressure of 130 to 230lb. to the square inch, and so these resistances are considerably reduced: they come down, in fact, to about one-twentieth of their initial value. When Ewing specially applied compressing forces, which were as large as 670lb. to the square inch, which would of themselves ordinarily, in a continuous piece of iron, have diminished the magnetisability, he found the diminution of the magnetisability of iron itself was nearly compensated for by the better conduction of the cut surface. The old surface, cut and compressed in that way, closes, as it were, magnetically up—does not act like a cut at all; but at the same time you lose just as much as you gain, because the iron itself becomes less magnetisable.

The above results of Ewing's are further represented by the curves of magnetisation drawn in Fig. 48. When the faces of a cut were carefully surfaced up to true planes, the disadvantageous effect of the cut was reduced considerably, and, under the application of a heavy external pressure, almost vanished.

I have several times referred to experimental results obtained in past years, principally by German and French workers, buried in obscurity in the pages of foreign scientific journals. Too often, indeed, the scattered papers of the German physicists are rendered worthless or unintelligible by reason of the omission of some of the data of the experiments. They give no measurements perhaps of their currents, or they used an uncalibrated galvanometer, or

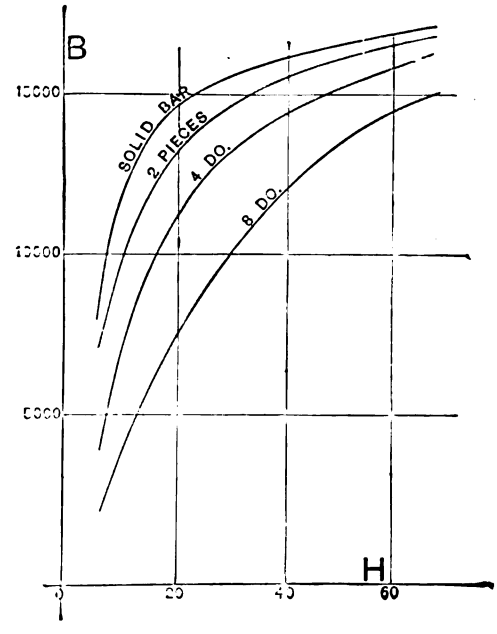

FIG. 48.—Ewing's Curves for Effect of Joints.

they do not say how many windings they were using in their coils; or perhaps they give their results in some obsolete phraseology. They are extremely addicted to informing you about the "magnetic moments" of their magnets. Now, the magnetic moment of an electro-magnet is the one thing that one never wants to know. Indeed the magnetic moment of a magnet of any kind is a useless piece of information, except in the case of bar-magnets of hard steel that are to be used in the determination of the horizontal component of the earth's magnetic force. What one does want to know about an electro-magnet is the number of magnetic lines flowing through its circuit, and this the older researches rarely afford the means of ascertaining. Nevertheless, there are some investigations worthy of study to which time will now only permit me very briefly to allude. These are the researches of Dub on the effect of thickness of armatures, and those of Nicklès and of Du Moncel on the lengths of armatures. Also those of Nicklès on the effect of width between the two limbs of the horse-shoe electro-magnet.

I can only now describe some experiments of Von Feilitzsch upon the vexed question of tubular cores, a matter touched by Sturgeon, Pfaff, Joule, Nicklès, and later by Du Moncel. To examine the question whether the inner part of the iron really helps to carry the magnetism, Von Feilitzsch prepared a set of thin iron tubes which could slide inside one another. They were all 11 centimetres long, and their peripheries varied from 6·12 centimetres to 9·7 centimetres. They could be pushed within a magnetising spiral to which either small or large currents could be applied, and their effect in deflecting a magnetic needle was noted, and balanced by

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means of a compensating steel magnet, from the position of which the forces were reckoned and the magnetic moments calculated out. As the tubes were of equal lengths, the magnetisation is approximately proportional to the magnetic moment. The outermost tube was first placed in the spiral, and a set of observations made; then the tube of next smaller size was slipped into it, and another set of observations made; then a third tube was slipped in until the whole of the seven were in use. Owing to the presence of the outer tube in all the experiments, the reluctance of the air return paths was alike in every case. The curves given in Fig. 49 indicate the results. The lowest curve is that corresponding to the use of the first tube alone. Its form, bending over and becoming nearly horizontal, indicates that with large magnetising power it became nearly satu-

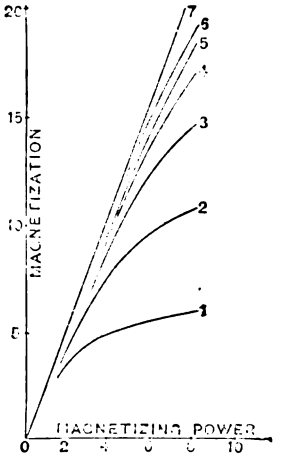

Fig. 49.—Von Feilitzsch's Curves of Magnetisation of Tubes.

rated. The second curve corresponds to the use of the first tube with the second within it. With greater section of iron saturation sets in at a later stage. Each successive tube adds to the capacity for carrying magnetic lines, the beginning of saturation being scarcely perceptible, even with the highest magnetising power, when all seven tubes were used. All the curves have the same initial slope. This indicates that with small magnetising forces, and when even the least quantity of iron was present, when the iron was far from saturation, the main resistance to magnetisation was that of the air paths, and it was the same whether the total section of iron in use was large or small.

I must leave till my next lecture the rules relating to the determination of the windings of copper wire on the cores.

ON THE INFLUENCE OF ELECTRIC PRESSURE ON INSULATION, ESPECIALLY WITH REFERENCE TO CABLES.*

BY C. HEIM, HANOVER.

With the increase in the number and size of electric installations the question of insulation has assumed greater importance. It has been already pointed out by Uppenborn that the insulation resistance is not independent of the pressure, but diminishes as the latter increases. The quantitative results that follow will, however, be of interest, especially as the tendency of late years has been towards a continual increase of the pressure in main conductors, and this interest will be increased owing to the bearing which the tests have on the question as to the durability of the insulation; for since the resistance falls with an increase of pressure, it seems likely that high volts cause a change in the nature of the insulating substance.

It is also to be remembered that these tests have a bearing on telegraph cables in which a high pressure is frequently employed.

Experiments were undertaken with lead-covered and with gutta-percha cables, and tests were also made with the field winding of a dynamo, an ordinary electric light wire attached to a wall, a bell-wire, and an aerial wire suspended on porcelain insulators. As will be seen, the question as to whether the influence varies with the temperature was only investigated in one case—that of the dynamo winding. All the other tests were made at the ordinary temperature of the room.

After I had commenced these investigations, Forderreuther published his observations on "Insulation Measurements of Electric Light Conductors." I, however, continued the work which I had begun, the limit of pressure employed by him having been only 89 volts.

Material Tested.—For my tests on cables I had available two bare lead cables 1,000m. long, by different makers, and a gutta-percha cable 800m. long. The dimensions of the lead cables were:—

No. I.—Diameter of core, 1·4mm.; diameter of insulating sheath, 5·3mm.

No. II.—Diameter of core, 1·1mm.; diameter of insulating sheath, 3·4mm.

Their capacities, as obtained by Thomson's compensation method, were:—

No. I. —0·137 microfarad at 15·5° Cent.
No. II.—0·135 ,, 15·7° ,,

As will be seen from the dimensions, the insulations in the two specimens were totally different. No. II. was in two pieces of 826 mm. and 174 mm. in length respectively. For such measurements as were taken it is clear that these cables were amply large enough. Also the absolute value of the insulation resistance agrees in all cases so long as the proportion between the diameter of the copper core and the insulating sheath remain constant. The gutta-percha-covered cable had a core of seven wires of ·7 mm. diameter covered with two layers of gutta-percha to the diameter of 5 mm. This cable corresponds with the underground cables laid by the German Telegraph Department. The gutta-percha was pure, and the insulation free from faults. The capacity of the cable was ·190 microfarads at 14·5°C.

Measurement.—The measurements were taken with a Thomson's astatic mirror galvanometer. Four shunts were used and a vulcanite commutator, also a rheostat of 100,000 ohms resistance. The galvanometer and shunts, &c., were carefully insulated from earth by means of vulcanite pedestals, and for every observation the leakage current was measured and allowed for. The sensibility of the galvanometer was adjusted by cutting out some of the electro-magnets, when it was made a maximum 100 volts, though a resistance of 500,000 megohms gave a displacement of 1 mm. on a scale 2 metres distant. The battery consisted of 330 small copper elements, to which could be added 60 accumulator cells, so that 460 to 470 volts were available. The Daniell cells were filled with a 5 per cent. solution of zinc sulphate, and in each about 15 grammes of copper sulphate were placed. It was found to remain very constant for three months, the volts in that period falling only from 1·06v. to 1·02v. per cell. The connections were so arranged that the primary cells could readily be switched in or out ten at a time, and the secondary cells in two equal halves.

Tests.—The observations could apparently be most simply carried out by taking a series of measurements of the insulation resistance either with increasing or decreasing pressures. Two points, however, have to be considered. On the one hand, any change of temperature, even if very slight, might utterly upset the results, owing to the high temperature coefficient of the insulation. Consequently, changes of temperature are to be guarded against, and the observations ought therefore to be taken as rapidly after one another as possible. On the other hand, this condition can only be partly complied with, as if a certain time is not allowed to elapse, a residual charge is left in the cable depending in magnitude on the volts and duration of the previous charge, and which may practically operate either to increase or to decrease the apparent voltage.

To keep the temperature constant, the following precautions were taken: The gutta-percha cable was placed in a wooden barrel containing about 70 litres of water. This was enclosed in a wooden casing filled with sawdust, which formed a cover nowhere less than 8 or 10 cm. thick. The two cable ends, about 1 metre long, passed through an opening in the top closed with a cork, and a thermometer was placed in a gas tube lined with cork and passed through the sawdust, the lower end of the thermometer projecting into the centre of the coil of cable.

For the 2-lead cable, corks of sufficient size were not at hand. In their case the temperature was kept constant by wrapping them in a covering of straw 10 cm. thick, which was enclosed in a layer of pasteboard. The cables were placed in a room where very little change in the temperature took place, the greatest variation during 24 hours not exceeding 1deg. For several weeks the temperature remained between 17deg. and 19deg. The ends of the cables were brought into the testing-room through a hole in the wall. During the course of a series of tests, lasting perhaps four or five hours, the thermometer belonging to the gutta-percha cable usually showed no change whatever, whilst that of the thinner of the lead cables was constant within ·1deg. All the cable ends were provided with Frölich's insulating caps, 9 cm. long. One end of each cable was brought to the measuring table, being connected to the instrument by a short length of wire passing through air.

A very exact check on the alterations of temperature in the cables may be obtained from the measurement of the alteration of

* From the *Elektrotechnische Zeitschrift.*

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the resistance of the copper core. This can be done as follows :—The cable K and a plug rheostat r of German silver wire are connected in series and coupled with a battery (Fig. 1). The cable K and the rheostat r are each put in shunt with one circuit of a differential galvanometer G (in my tests one of Wiedemann's was used). A current of about one-tenth ampere is allowed to flow through K and r. The resistance of r is made equal to that of K within one-tenth of an ohm. The resistance of this part of the circuit can then be made exactly equal to that of K by putting a high resistance R in parallel with r. From the readings taken we get the temperature of r, and thence that of K. The temperature coefficient of German silver being ten times lower than that of copper, an error of ·1deg. in the determination of the temperature of the rheostat only produces one of ·01deg. in that of the cable.

A large number of measurements of the insulation at various pressures have to be taken. At the end of any series of tests, and usually also after the measurement at an intermediate pressure, the insulation resistance is again measured at the low original pressure. From the difference between these two values a very slight alteration in temperature is easily detected, the method being very much more delicate than that of measuring the resistance of the copper core as above explained. This slight alteration having been determined, the correction it necessitates can easily be applied. The exact procedure is as follows :—The interval for discharge has to be suited to the pressure ; thus, if the latter is 50 volts, the cable has both ends connected to earth for 40 minutes ; if 460 volts, for two hours ; 200 volts, for 1¼ hours ; and so on. Consequently the time of the measurement with high volts is nearer to the former than to the latter of those at lower tension ; and this has to be taken into account in deducing the value of the insulation resistance at the low tension for comparison with that at the high tension. If more than two different pressures were tested, all readings were in

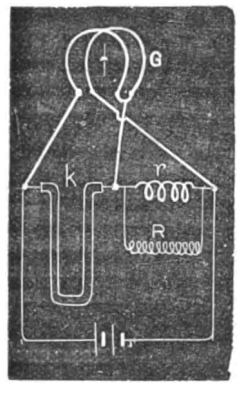

Diagram of Connections for Insulation Tests.

the same way reduced to the time of one, usually the intermediate pressure.

In order to make the residual charge as small as possible, the time of connection to the battery must be short. I therefore took readings one and two minutes after closing the circuit. I did not consider that the former would be sufficient taken by itself, partly because it gave no control or safeguard against error, and partly because the length of time occupied by the swinging of the galvanometer mirror, together with the rapid change in the current passing, made it more difficult to take the reading after one minute than it was after two. It should be observed that the short-circuiting key of the galvanometer was not taken out until 10 seconds after the cable had been coupled to the battery.

In spite of the long time allowed for discharging the cables they showed signs of residual charge, especially after high volts had been used. Immediately before a fresh reading was taken, the cable was connected to earth through the galvanometer and the slight displacement was observed. If this exceeded ½ per cent. of that afterwards obtained. I added it to the latter, and calculated the insulation resistance from the sum. That this method was pretty correct is proved by the following :—In tests during which neither the thermometer nor the copper resistance showed any change of temperature, the insulation resistance at the low-pressure at the end of the series of tests was found without the above correction, always to be lower than that found at the beginning ; whereas if the correction was employed the two values agreed. Moreover, this process seems to be justified by the consideration that the residual charge, supposing that the same pole is used, acts as an opposing electromotive force, and that such residual charges, as Frölich observed, and I myself found, remain for a very long time in cables, and cannot be obliterated even by a short charge from the opposite pole.

For any series of tests on one cable the sensibility of the galvanometer was adjusted one hour before starting, and every correction for resistance in connecting wires, &c., was duly made.

In the case of electric light cables and others carrying a current for a considerable length of time, the value of the insulation resistance after one or two minutes is not so important as that reached after a longer time. Frölich has concluded that in the case of a gutta-percha cable it approaches a constant value. I have made experiments to ascertain if Frölich's results hold good for various temperatures, the cable for that purpose being connected to the battery for a quarter of an hour.

Table I. opposite will show the method of applying the corrections mentioned above in the case of the gutta-percha cable.

Tables II., III. and IV. give the corrected values of the insulation resistances for the three cables at various pressures.

The experiments, therefore, prove that a fall in the insulation resistance does undoubtedly take place as the pressure increases in the cases of the tables that I tested, but that within the limits of pressure I employed the variation is small. It is also clear that this rate of diminution varies for different dielectrics.

It is also interesting to note the influence of the time during which the circuit has been closed on the insulation resistance. As may be seen from Tables II. to IV., this influence is far more noticeable in the 2-lead cables than in the gutta-percha cable. In order to investigate this point further, the observations were carried on for a period of 15 minutes with the results shown in Table VI.

Representing the value of the insulation resistance after one minute by unity, as is done by Frölich, the results for the gutta-percha cable are as follows :—

Observer.	Pressure Volts.	1	2	3	5	10	15 mins.
Frölich	?	1·00	1·11	1·15	1·24	1·33	1·37
Heim	53	1·00	1·13	1·20	1·27	1·35	1·40
	213	1·00	1·14	1·21	1·30	1·38	1·46
	270	1·00	1·13	1·19	1·28	1·36	1·42

My observations were taken at 16·5deg. Frölich gives results for 16deg. and 18deg., from which those given above under his name are calculated. The slight difference is probably due to the nature of the gutta-percha.

For the two lead cables I got

	Pressure.	1	2	3	5	10	15 mins.
Lead cable No. 1	21	1·00	1·25	1·54	1·96	2·83	3·59
	213	1·00	1·25	1·49	1·96	2·88	3·64
	470	1·00	1·25	1·47	1·92	2·80	3·52
Lead cable No. 2	53	1·00	1·37	1·66	2·02	2·74	3·24
	213	1·00	1·42	1·72	2·16	2·82	3.26

It is therefore clear that for conductors supplying current continuously the insulation resistance should be measured not only one and two minutes after closing the circuit, but also say after the expiration of half an hour.

Observations were also undertaken with the view of ascertaining whether changing the direction of the current would produce any alteration in the insulation resistance, but no very marked difference was observable.

For the tests on a dynamo winding, one of Schuckert's shunt-wound disc machines, capacity 100 volts × 5 amperes was used. The readings were taken after the circuit had been closed one minute, precautions being adopted as in the case of the cables and similar corrections being applied. The machine was tested both hot and cold. The field winding, which consisted of 5,500 turns of double cotton covered wire ·8mm. thick, was warmed by passing through it for six hours a current at the rate of 2 amperes per square millimetre of copper section.

The tables opposite show the results obtained.

Two conductors of types usually attached to walls were also tested. A was a flexible cord of 19 wires of 1·2 mm. diam., insulated first with asbestos ribbon, then with india rubber, and covered with yarn. It was 150 m. long, and attached to the wall of a room near the ceiling by twined cleats on wood bases. B was an ordinary bell wire, ·9 mm. thick, insulated with double cotton and paraffin ; it was 170 m. long, and attached to a wall by staples. The tests gave the results shown in Tables VII. and VIII.

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Table I.—*Gutta-Percha Cable.*

Time.	Pressure in volts.	Observed Deflection.	Deflection due to leakage current.	Deflection due to residual charge.	Correction proportional to the tangent.	Corrected deflection.	Sensibility.	Insulation resistance.	Insulation resistance reduced to time 1hr. 17m.
		Mm.	Mm.	Mm.	Mm.	Mm.	Ohms.	Megohms.	Megohms.
9h. 34m.	52	1min. 26·2	0·2	...	0·0	26·0	201,700	7,760	8,070
		2 23·1	...	...	0·0	22·9	...	8,820	9,140
10 " 34	208	1 105·6	0·6	∠ 0·1	−0·1	104·9	806,000	7,670	7,880
		2 93·1	...	...	−0·05	92 45	...	8,710	8,930
1 " 17	460	1 264·0	1·4	0·4	−1·2	261·8	1,884,000	7,210	7 210
		2 233·5	...	...	−0·8	231·7	...	8,145	8,145
3 " 32	52	1 25·3	0·2	0·55	0·0	25·65	211,700·	8,260	...
"	"	2 22·35	...	...	0·0	22·7	...	9,335	...

Table II.—*Insulation Resistance of the Gutta-percha Cable at different Tensions in Megohms.*

Number of test.	Minutes after closing circuit.	Pressure in volts.			Temperature of the water.
		52	208	460	
1	1	7,985	...	7,600	16·45°
	2	9,160	...	8,670	
2	1	7,990	...	7,620	16·5°
	2	9,060	...	8,610	
3	1	8,070	7,880	7,210	...
	2	9,140	8,930	8,145	
4	1	7,870	7,790	7,200	16·4°
	2	8,800	...	8,210	
5	1	8,150	...	7,590	16·25°
	2	9,370	...	8,630	
6	1	8,370	...	7,820	15·75°
	2	9,740	...	8,955	
7	1	8,240	8,065	7,770	15·70
	2	9,520	9,370	8,930	
8	1	7,190	7,020	6,810	16·70
	2	8,260	8,045	7,710	

Table III.—*Insulation Resistance in Megohms of Lead Cable, No. 1, at Different Pressures.*

Number of test.	Minutes after closing circuit.	Pressure in volts.				Temperature.
		21	52	208	460	
1	1	...	1,955	1,940	1,890	18·15°
	2		2,510	2,490	2,440	
2	1	...	2,130	2,120	2,080	17·7°
	2		2,695	2,680	2,640	
3	1	...	2,129	2,110	2,070	17·7°
	2		2,680	2,660	2,625	
4	1	2,410		2,355	2,330	17·1°
	2	3,010	...	2,925	2,900	
5	1	1,850	1,840	1,810	1,770	18·4°
	2	2,380	2,380	2,320	2,299	

Table IV.—*Insulation Resistance of Lead Cable in Megohms, No. 2, at Different Pressures.*

Number of test.	Minutes after closing circuit.	Pressure in volts.				Temperature.
		52	104	208	460	
1	1	13,500			13,200	17·9°
	2	19,500	...	...	17,750	
2	1	13,600	13,300	13,000	12,500	18·3°
	2	19,150	18,000	17,600	17,200	
3	1		15,150		14,600	17·0°
	2	...	21,700	...	20,500	
4	1		14,900	14,800	14,400	17·4°
	2	...	21,400	20,800	20,100	
5	1	15,500	15,300		14,950	17·0°
	2	21,700	...	...	20,800	
6	1	13,400	13,200	13,000	12,400	18·7°
	2	18,500	18,100	17,850	17,100	

Table VI.—*Insulation Resistances at different Pressures and at different times after closing the Circuit.*

Description of cable.	Pressure in volts.	Insulation resistance in megohms. Number of minutes after closing circuit.					
		1	2	3	5	10	15
Gutta-percha cable	53	7,500	8,495	9,020	9,530	10,100	10,540
	213	7,200	8,250	8,740	9,370	9,950	10,480
	470	7,050	7,960	8,420	9,015	9,570	10,000
Lead cable No. 1.	21	2,290	2,870	3,530	4,495	6,480	8,215
	213	2,185	2,730	3,250	4,280	6,280	7,955
	470	2,180	2,720	3,210	4,190	6,090	7,670
Lead cable No. 2.	53	14,750	20,200	24,450	29,800	40,500	47,700
	213	13,500	19,200	23,200	29,200	38,100	43,950

Table V.—*Fall in insulation resistance, with increased pressure as a percentage.*

Minutes after closing circuit.	Gutta-Percha Cable.			Lead Cable No. 1.					Lead Cable No. 2.			
	No. of test.	Incr. Pressure. Volts.		No. of test.	Increase of Pressure. Volts.				No. of test.	Increase of Pressure. Volts.		
		52 to 460	52 to 208		52 to 460	52 to 208	21 to 460	21 to 208		52 to 460	52 to 208	104 to 460
		Per cent.	Per cent.		Per cent.	Per cent.	Per cent.	Per cent.		Per cent.	Per cent.	Per cent.
1	1	4·8	...	1	3·3	0·77	...	...	1	2·2	...	...
2	"	5·4	...	"	2·8	0·80	...	...	"	9·0	...	...
1	2	4·6	...	2	2·3	0·47	...	...	2	8·1	4·4	6·0
2	"	5·0	...	"	2·0	0·56	...	...	"	10·0	8·1	4·4
1	3	10·6	2·4	3	2·4	0·47	...	...	3	...	...	3·6
2	"	10·9	2·3	"	2·1	0·75	...	...	"	...	...	5·5
1	4	8·5	1·0	4	...	...	3·3	2·3	4	...	...	3·4
2	"	6·7	...	"	...	...	3·7	2·8	"	...	...	6·1
1	5	6·8	...	5	3·8	1·6	4·3	2·2	5	3·5	...	2·3
2	"	7·9	...	"	3·8	2·5	3·8	2·5	"	4·1	...	...
1	6	6·6	...	...	...	...	...	...	6	7·5	3·0	6·0
2	"	8·1	...	...	...	...	...	...	"	7·6	3·5	5·5
1	7	5·7	2·1	...	...	...	...	...	...	...	...	...
2	"	6·2	1·6	...	...	...	...	...	...	...	...	...
1	8	5·3	2·4	...	...	...	...	...	...	...	...	...
2	"	6·7	2·6	...	...	...	...	...	...	...	...	...
1	Mean	6·6	2·0	Mean	2·9	0·81	3·8	2·3	Mean	5·3	3·7	4·3
2	"	7·1	2·2	"	2·7	1·15	3·3	2·7	"	7·7	5·8	5·4

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Table VII.—*Insulation resistance of the field-winding of a dynamo in megohms, measured one minute after closing the circuit, and with the machine hot and cold :—*

Time.	Pressure in volts.				Temperature.	
	2	20	102	400		
h. m.					deg.	
3 15	...	6·16	...	...	17·2	Machine cold.
3 36	...	...	3·72	...	17·1	
4 24	...	6·53	...	...	...	
4 47	...	...	...	2·72	17·3	
5 46	...	6·68	...	...	17·3	
3 52	17·0	...	...	...	17·1	Machine cold.
4 23	...	8·00	...	...	17·1	
5 34	17·2	...	...	...	17·2	
5 50	...	...	4·66	...	17·2	
10 42	...	0·75	...	...	...	Machine hot.
11 35	...	...	0·55	...	...	
12 35	...	1·01	...	...	...	
1 3	...	...	...	0·50	...	
4 10	...	0·82	...	...	...	
4 41	...	...	0·67	...	...	
5 12	...	1·02	...	...	...	

Table VIII.—*Insulation resistance of two conductors, A and B, one minute after closing the circuit.*

Pressure in volts.	Insulation resistance in megohm.	
——	Conductor A.	Conductor B.
2	0·63	0·124
20	0·58	0·091
2	0·61	0·117
120	0·50	0·085
2	0·75	0·111
20	0·57	0·100
2	0·60	0·119

THE DISCHARGE OF ACCUMULATORS LEFT ON OPEN CIRCUIT.*

BY GASTON ROUX.

When it is not required to make use of a battery of accumulators during a certain period, what must one do to prevent them from being injuriously affected? That is a question which has often been put to me, and to which I have always replied :—"Charge the battery to "saturation," and leave it to itself." I am aware that this is not the opinion of everyone, and that some recommend that accumulators should be charged to "saturation," and the liquid then emptied out, while others advise substituting pure water for the ordinary solution, and others still the substitution of concentrated acid for the ordinary solution. My opinion was based upon an experiment which I carry out each year at the École de Physique et Chimie Industrielles de la Ville de Paris during the summer holidays. The experiment was repeated as usual this year, and I determined the exact amount of charge lost by the accumulators left on open circuit. The tests were made on two storage cells of the Julien type, having capacity of 200 ampere hours, which were separated from the remainder of the battery. These accumulators are provided with paraffin spray arresters. The cells are of glass, and are contained in wooden boxes filled with sawdust, and supported on oil insulators. The cells, therefore, are thoroughly well insulated. The solution has a density of 1·2, when the cells are fully charged, and contains 6 per cent. in volume of saturated sulphate of soda.

The two cells were charged to saturation on August 5th, discharged on August 6th, and recharged on the 7th of the same month. I then left them to themselves until October 20th, that-is to say, for two months and 13 days, when they were discharged. The discharge was stopped both on August 6th and October 20th, when the E.M.F. had fallen to 1·8 volts per cell. The quantity of electricity was found to be 233 ampere hours on August 6th, and 220 ampere hours on October 20th. Assuming that in each charge the accumulators stored the same quantity of electricity, we may conclude that the accumulators only lost on open circuit 13 ampere hours, or 6 per cent. of their charge during two and a-half months. This result seems to me to prove that accumulators well-made, well-charged, and well-insulated, are not injured by being left on open circuit. It also shows the good quality of these particular cells, and proves again that there is no local action between the active material and the antimony alloy supports. I should have liked to have carried out a similar test on accumulators with plain lead grids, but I had none at my disposal.

* From *L'Électricien*.

GERMAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

October 28, 1890.

The engineers of the Cologne municipal gasworks have commenced to lay the concentric mains for electrical supply in that town. These cables have been manufactured by MM. Chandoir of Neufchâtel, and are the first of their kind laid down in Germany in connection with a Ganz station. The cables must have an insulation resistance of at least 1,000 megohms per kilometre, and are also tested under a pressure of 5,000 volts ; the working pressure being 2,000 volts. The first batch of mains tested under an E.M.F. of 120 volts had a resistance of 16,000 megohms per 1,000 metres. The cables are protected against mechanical injury by wooden troughing, which is filled in with a mixture of resin and oil. The first group of machinery installed will comprise 2,500 horse-power and 1,125 horse-power dynamos. These machines are coupled direct to Sulzer engines, running at 85 revolutions per minute. The alternators have 72 poles, so that the current has a periodicity of 51. The armature of the exciter revolves on the spindle of the field-magnets of the alternator, and the frame carrying the alternator armature coils also carries the eight poles of the exciter. As the Helios Company, which is erecting this central station, make a small arc lamp which burns splendidly with a D.P. of 32 volts, the secondaries of the transformers are wound to give 72 volts, so that two of these lamps may be run in series across the house circuits without excessive waste of power.

Herr A. Schneller has forwarded me the following values for spark-lengths at high voltages. The readings were taken by means of a Cardew voltmeter connected across the primary terminals of a "step-up" transformer. The spark-lengths were fixed beforehand by setting the wires at measured distances apart, and increasing the pressure till a spark took place. The results obtained are shown in the accompanying table :—

Pressure.	Sparking distance mm.	Pressure.	Sparking distance mm.
4,300	4	10,700	16
4,700	6	11,500	20
6,750	10	13,100	22
7,800	16	14,200	24

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *October* 25, 1890.

The Vienna streets have been "up" all this summer. Wherever one walks the pavements are blocked, and the work still goes on, day and night. The International Electricitäts Gesellschaft and Messrs. Siemens and Halske are laying electric light cables all over the city; and both firms hope to commence lighting up the districts assigned to them before the end of the year, and both state that they have large orders on hand for private houses and shops. To add to the confusion, the Vienna Telephone Company are extending their underground network, and adding about 2,000 subterranean lines to the present number. All over the Empire there has been great activity in extending the electric light and electric traction. In Vienna the two firms mentioned above divide the city proper, but Messrs. Cappilleri, Holzapfel and Co. have secured the concessions for Wahring Kernals, Ottaking, and Neulerchenfeld, suburbs of Vienna. The Mariahilf district of Vienna is being supplied by a local company. The Agricultural and Forestry Exhibition is, it is needless to say, also lit by electric light, the largest installation there being that of Messrs. Siemens and Halske, who evidently mean to remain the premier firm on the Continent. They have there a 850 horse-power installation, 675 horse-power being used to drive the 16 dynamos, which supply 400 arc and 2,000 glow lamps. The central station of the International Electricitäts Gesellschaft, near the Danube, will have an output of over 2,000 horse-power. The interior installation of the Palace is to begin with 8,000 glow lamps, and the contract for the wiring has been given to the firm of Egger and Co., who have already carried out the installations for the Imperial Court in Gastein, Lainz, and Ischl.

Much surprise has been expressed in Vienna that the Imperial Continental Gas Association have not made better use of their opportunities. They were practically the first in the field here with their splendid central station for lighting up the Court Theatre.

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They paid the "apprentice money" every new enterprise has to pay, and were in the position to secure the best part of the town; but they seem to have got frightened and missed their opportunity, and to have rested content with what they had, so that they will soon have to encounter serious competition with the various electric light companies.

As to traction work, the Weiner Tramway Gesellschaft has laid a bill before the Austrian Chamber authorising the building of an electric subway railway under the centre of the city.

The Budapest Town Council are building an electric tramway to Steinbruch, three kilometres distant, and are going to use the Ganz system. The Tram Company of the same city have also applied for a concession to run an electric tramway on the right bank of the Danube.

Vienna has not been behind the times in respect of telephony. To-day the best equipped and largest single central station is that in Vienna. It is built for 5,000 subscribers, and fitted up with M. Otto Schaffler's splendid multiple board. Some 3,000 subscribers are already connected up, and cables are now being laid for 2,000 more. The Company expect to fill their exchange by next year, and have already over 1,000 orders on hand. The service is excellent both in Vienna and in Prag, and it has stood the severe test of the use of the long trunk line between these two towns. Over 95 per cent. of the communications over this trunk line were direct communications from a Prag subscriber to a Vienna subscriber, very few using the call rooms. Vienna, besides being connected by special trunk lines with the small towns south as far as Reichenaü, and with Prag and Budapest, has now also been connected by special wire with Brünn, and the Van Rysselberghe mongrel wire is to be reconverted into an ordinary telegraph wire. Prag has also been connected with the North Bohemian coal district, Aussig, Teplitz, &c., and Reichenberg with Gablonz. Next year it is proposed to connect Reichenberg with Prag, and, perhaps, also with Zittai, in Saxony. A special trunk line is also proposed, connecting Vienna with Grez and Trieste, but this will probably take two or three years yet before it is realised. The provincial towns also have not been behindhand, and the subscribers in the eight towns worked by the Telephone Company of Austria have increased to 3,157, with 6,572 kilometres of wire run.

CORRESPONDENCE.

THE TELEPHONE SUGGESTED IN 1854.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We are all familiar with the earlier telephonic experiments of Reis which are given in the *Jahres Bericht des Physikalischen Vereins*, of Frankfort, for 1860-61, and which are regarded as the precursor of the telephone of Graham Bell. Prof. Bell read a Paper on the subject before the Society of Telegraph Engineers on October 31, 1877; and at this lecture I called attention to a still earlier description of a telephone by Charles Bourseul, which is to be found in the second edition of the Comte Theodore du Moncel's *Exposé des Applications de l'Electricité*, published in Paris in 1857 (Vol. III., p. 110). Du Moncel does not give any reference to the original Paper; but in the *Didaskalia*, a weekly paper published at Frankfort-on-Main, No. 232, dated September 28, 1854, there is an interesting account of his invention which I do not remember to have seen printed in England. I am indebted to Messrs. Siemens Brothers and Co. for making the translation which I enclose, and, if not hitherto published, it will, I am sure, interest your readers, as his description of the principle of the telephone is almost as clear as if it were written at the present date. If he had only put his ideas to the test of experiment, we should have had the telephone in 1854.

It would be interesting to find the original source from which Count du Moncel derived his account of Bourseul's telephone.—Yours, &c.,

LATIMER CLARK.

6, Westminster-chambers, Victoria-street, London,
October 28, 1890.

Didaskalia, No. 322, Thursday, September 28, 1854.

ELECTRICAL TELEPHONY.

The number of miracles with which electricity has astonished us lately is said to have been increased by one which would not only cause a revolution in electrical telegraphy, but would add considerably to its utility. The invention in question is nothing less than the electrical transmission of the "*spoken word*." The idea was conceived by an educated and modest young man named Charles Bourseul (now living in Paris), who was a private in the African army in 1848, where he brought himself under the notice of the Governor-General by a course of mathematical lectures which he gave to his comrades in the garrison of Algiers. Possibly Bourseul's scheme, of the practicability of which he is perfectly convinced, may be one of those which learned men will afterwards declare very simple, and which, if troubled about, would have been brought out much sooner. The principle of electro-telegraphy, as is well known, is the following: an electric current passing through a metal wire surrounding a piece of soft iron, transforms the latter into a magnet. The magnetic properties of the iron vanish when the electric current is discontinued. This magnet, called the electro-magnet, can, therefore, alternately attract or repel a movable plate which by its forward and backward movements produces the conventional signals used in telegraphy. It is further known that all sounds are transmitted to the ear through the air vibrating; and that, therefore, sounds are virtually vibrations of the air and that the infinite variety of sounds is solely dependent on the rapidity and strength of these vibrations. If it were possible to construct a metal plate sufficiently sensitive and flexible to admit of the reproduction of the vibration of sounds (like the air), and if this plate could be connected with an electric current in such a manner as to alternately interrupt and continue it according to the vibrations of the air to which it would be exposed, it would be equally possible to electrically affect a similar metal plate so as to repeat exactly and simultaneously the vibrations of the first plate. This would create the impression as if the speaker had spoken in immediate vicinity of the second plate, or, if put differently, the ear would be affected in a similar way as if it had received the sounds through the first metal plate. Electrical telegraphy, which was once academically declared to be almost an absurdity, is now almost universally established; and if we investigate this new idea of the young scientist on the principles of physics, we find that not only no objection could be raised against the soundness of his theory, but that its practicability is more probable than that of electrical telegraphy was only a short time ago. If the theory should prove a success, electrical telegraphy will attain a position of general usefulness. No special knowledge or apparatus will be required, except a galvanic battery, two suspended plates, and a metal wire. Without any other preparation one person will have to speak into one of the plates, while the other person places the second plate close to his ear, thus enabling them to converse as if in private.

The youthful inventor is confident of the success of his invention, and challenges scientists to prove the impracticability of his theory on scientific grounds. In the meantime the invention fully deserves the attention which will, no doubt, be bestowed on it. L.

TRADE NOTES AND NOTICES.

TENDERS WANTED.—The Corporation of Monmouth require tenders for the electric lighting on the low-tension system of the streets of Monmouth. Persons tendering are to supply, erect, and fix all the necessary plant, machinery, engines, boiler, dynamo, conductors, &c. Tenders are to be sent in to the Town Clerk, Monmouth, by Saturday, the 18th November next.

SALE OF ELECTRICAL PLANT.—An unusual opportunity is afforded by the sale, which takes place to-day, for the purchase of some first-rate machinery, which is probably in a better condition than when it left the makers' works. The reason for the sale, of which particulars will be found in our advertisement columns, is that the Westminster Electric Supply Corporation have purchased the business of the Westminster Electric Light Syndicate, but do not intend to use the alternating-current system, which the latter Company was employing.

ELECTRICAL ENGINEERING CORPORATION (LIMITED).—We have been favoured with a copy of a well-illustrated and a very exhaustive catalogue of the manufactures of this Corporation. These manufactures cover a very wide range in electrical engineering, and the catalogue gives very full particulars and prices relating to constant-current dynamos, alternate-current machinery, engines, the telpher system of cheap transport, tramways, light railways, &c., plant for supply stations, machinery for transmission of power, electrical supplies, &c. The book contains nearly 100 large folio pages, and is altogether one of the most complete catalogues we have seen. We notice that the Corporation supply connecting sockets, which are the only proper and thoroughly workmanlike mode of fastening large cables to dynamos and switch-boards. They also supply another useful and little known device—viz., a two-way switch, by which lights may be turned on from one point and turned off from another.

MESSRS. W. H. ALLEN AND CO.—This firm have received the order to fit up the whole of the fleet of steamers Messrs. Harland and Wolff have now on the stocks, six in number, with electric light. Messrs. W. H. Allen and Co. state that they are the only firm in England who manufacture under the same roof the whole of the gear required for marine electric light work, having been manufacturers of both dynamos and engines for some years past. The improvements which they have recently carried out in their governors for marine work enable the engine to be under entire self-control.——Messrs. W. H. Allen and Co. announce that Mr. R. W. Allen, eldest son of the senior partner in this firm, was on the 27th inst. taken into partnership. In the circular notice of this change in the constitution of the firm, reference is made to the

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large business done by the Company, and to the very large extension of premises which the Company have recently made.

MR. JOHN JARDINE.—We have received from Mr. Jardine his price list and discount sheet of shafting and shafting accessories, of which he makes a speciality. Illustrations of Mr. Jardine's various manufactures are given.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

October 16, 1890.

16,472. B. J. STACEY. London. A new or improved automatic coin-freed apparatus for giving electric shocks.

October 17, 1890.

16,518. J. E. A. GWYNNE. London. Improvements in arc electric lamps.

16,522. G. D. BURTON. London. Improvements in the methods of and apparatus for working metals by electricity.

16,534. A. LONGSDON. New or improved electrical priming, or electrical frictional priming screw plugs (F. Krupp, Germany.)

October 18, 1890.

16,556 W. P. THOMPSON. Liverpool. Improvements in devices for holding the receivers of telephone instruments, or the like (J. T. MOORE, United States.)

16,570. H. GROSWITH. Glasgow. Improvements in electric motors.

16,571. C. W. KENNEDY and H. GROSWITH. Glasgow. Improvements in secondary batteries.

16,603. C. J. HALL. London. Improvements in secondary batteries.

16,607. C. E. BONNE. London. Improvements in or connected with electric switches (W. P. Dorniels, Germany).

16,613 J. MÖHRLE. London. A method of renewing filaments in in candescent lamps.

October 20, 1890.

16,631. G. S. HOOKER. Bath. A switch for interchanging constant current dynamos without breaking the continuity of the circuit on to which they are to work.

16,653. S. C. C. CURRIE. London. Improvements in apparatus for measuring the strength of electric currents.

16,675. W. C. FISCHER. London. Improvements in water motors and in dynamo machines to be driven by same.

October 21, 1890.

16,747. J. R. THAME. London. Improvements in the manufacture of electrical insulating materials.

16,752. T. R. ANDREWS and T. PREECE. Bradford. Improvements in electrical switches.

16,792. A. DE PUYAT. London. An improved arrangement of regulating device for electric arc lamps.

October 22, 1890.

16,809. G. D. BURTON. London. Improvements in electric blank heating and feeding apparatus for forging machines.

16,811. P. G. POCHIN. Sheffield. The improvement of switchboards for the regulation and control of electrical currents.

16,821. T. HESKIN. Preston. Improvements in appliances for producing light by incandescence.

16,835. W. CAVINS and A. F. MABON. Glasgow. An improved electrical conductor for fitting in mine shafts and underground haulage roads for electrical signalling purposes.

16,837. J. E. DOUGLASS. London. Improvements in the manufacture, construction, and building up of secondary battery elements, electrodes, or plates.

16,844. H. WEYMERSCH. London. An improvement in the construction of accumulators or secondary batteries.

16,847. W. LOWNDS, E. EMANUEL, and J. WOOD. Chiswick. An improved electric switch.

October 23, 1890.

16,889. R. KENNEDY. Kilmarnock. Improvements in electro-motors.

16.934. M. AZAPIS. London. A new electro-battery.

16,958. J. A. BRYCE. London. A method of and apparatus for signalling by means of electricity.

October 24, 1890.

16,963. W. HARTNELL. Leeds. Improved means of placing conductors for electricity underground.

16.989. G. A. ZOBEL and C. STEWART. Edinburgh. Improvements in fire alarm telegraphs.

17,018. W. BISHOP. London. Improved joints or connectors for uniting wires or cables, temporarily or otherwise, for electrical or other purposes.

October 25, 1890.

17,035. J. LEA. Northampton. Improvements in electricity meters.

17,062. J. P. BAYLY. London. Improved electric switch (C. Herrick, United States).

17,063. J. P. BAYLY. London. An improved electric lamp holder and switch combined (C. Herrick, United States).

17,108. G. PITT. London. Improvements in dynamo-electric machines. (R. Thury, Switzerland.)

SPECIFICATIONS PUBLISHED.

1889.

15,963. SCHOOP. Electrodes for electrical batteries. (Price 6d.)

17,205. ELMORE. Obtaining zinc by electrolysis. (Price 4d.)

17,304. SMALLWOOD. Magnetic separators. (Price 11d.)

17,521. CLARK (Schuckert & Co.). Distribution, &c., of electric currents. (Price 11d.)

17,581. JOEL. Regulating, &c., electric currents. (Price 8d.)

17,652. RIDER. Electric arc lamps. (Price 6d.)

18,028. DE PASS (Société Jacquet Frères). Electric accumulators. (Price 8d.)

18,526. LAKE (Field). Transmitting telegraphic signals. (Price 8d.)

1890.

3,169. CARPENTER. Electro-heating apparatus. (Price 8d.)

9,780. SMITH and FOX. Electric railway signals. (Price 8d.)

12,532. PITT (Sautter, Harlé & Co.). Electric arc lighting. (Price 8d.)

13,635. THOMPSON (Coffin). Electric welding. (Price 6d.)

13,636. THOMPSON (Coffin). Electric welding. (Price 6d.)

13,802. WALKER. Electrical measuring instruments. (Price 8d.)

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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LEGAL INTELLIGENCE.

In the Court of Appeal of the Supreme Court of Judicature, on Saturday last (before the Master of the Rolls, Lord Justice Lindley, and Lord Justice Lopes), the action *in re* Brazilian Submarine Telegraph Company (Limited)—Chatenay *v* Brazillian Submorine Telegraph Company (Limited) came on for hearing.

This was an appeal from the decision of Mr. Justice Day. M. Chatenay, who resided and carried on business at Rio de Janeiro, was the owner of 50 shares in the Brazilian Submarine Telegraph Company. In May, 1880, he executed at Rio a "notarial act," which is, in effect, a power of attorney, and which gave power to P. Broë, of London, on behalf of M. Chatenay, of Rio, "to purchase and sell shares in public companies and public funds in conformity with his letters of credit and following his letters of orders and particular advices, which, if necessary, shall be considered as part hereof." Broë made use of this notarial act to transfer the fifty shares without any special order or direction from Chatenay to do so. Chatenay thereupon applied under the Companies Act for an order restoring his name to the register as owner of the shares. After argument in the Divisional Court, Mr. Justice Day held that, as the business was to be transacted in England, it must be construed in accordance with English law, and from this decision the Company now appealed.

In the end, the Appeal Court upheld the decision of Mr. Justice Day, and the appeal was dismissed.

COMPANIES' MEETINGS & REPORTS.

The Monte Video Telephone Company (Limited).

The following is the report of the Directors of this Company to be presented to the shareholders at the annual general meeting, to be held at the offices of the Company, 25, Abchurch-lane, London, E.C., this day (Friday):—

The accounts for the year ending July 31st last show a gross profit of £10,301 5s. 9d., after providing for all working expenses in Monte Video and London.

Off this sum there has been written £114 14s. 8d. for preliminary expenses, and £19 10s. 10d. for depreciation of furniture, leaving a balance of £10,167 0s. 3d. To this must be added the balance from last year, £325 8s. 5d., making a total now to be dealt with of £10,492. 8s. 8d.

The Directors recommend that of this amount the full dividend of 6 per cent. on the Preference Shares, amounting to £8,308 7s. 2d., be declared, that £1,000 be added to the Depreciation Fund, and that the balance, £1,184 1s. 6d., be carried forward.

An interim dividend on the Preference Shares was paid in March last.

During the year the sum of £5,600 6s. 7d. has been expended on capital account, chiefly in consequence of the completion of the fixture of the multiple switchboard, cables, and lines for new subscribers.

The Directors regret that the results for the past year have not come up to their expectations; but bearing in mind the severe commercial depression which for a considerable portion of that year has prevailed in Monte Video, and which has caused very many subscribers to curtail their expenses by relinquishing their subscriptions to the Telephone Exchanges, they cannot but deem it satisfactory to have maintained the profit at above £10,000. For these reasons it has not been deemed advisable to recommend any dividend on the ordinary shares. It is gratifying, however, to report that the latest advices from the manager are to the effect that a large number of subscribers who have left for a variety of reasons, have returned to the Company.

In accordance with the Articles of Association, Mr. Peters retires from the Board, but, being eligible, offers himself for re-election.

The Auditors, Messrs. Gérard Van de Linde & Son, also retire, but offer themselves for re-election.

[There was a dividend of 2½ per cent. paid on the ordinary shares last year.]

NEW COMPANIES REGISTERED.

BRITISH INSULATED WIRE COMPANY (LIMITED).—Registered by Thomas T. Hull, 22, Chancery-lane, W.C., with a capital of £60,000, in £5 shares. Object: to purchase or otherwise acquire any patents, brevets d'invention, licences, concessions, and the like, conferring an exclusive or non-exclusive or limited right to use any inventions capable of being used in the manufacture of wire and wire ropes and cables, or any other invention which may seem to the Company capable of being profitably dealt with. There shall not be less than three nor more than seven Directors; the first to be appointed by the subscribers to the Memorandum of Association. Qualification not specified. Remuneration, £200 and 10 per cent. of net profits after 10 per cent. dividend.

THE ELECTRO-CHEMICAL SYNDICATE (LIMITED).—Registered by Lovell and Trimnel, of Monument-buildings, London, E.C., with a capital of £5,000, in £1 shares. Objects: To acquire and turn to account inventions, patents, &c. Registered without articles of association.

CITY NOTES, &c.

BANKRUPT.—The bankruptcy is announced in Wednesday's *Gazette* of Henry Thompson, electrical case maker, Phœnix-place, Gray's Inn-road, and St. Peter's-street, Islington, London.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ended October 24th amounted to £1,834.

ELMORE'S FRENCH COPPER DEPOSIT COMPANY.—A call of 15s. on 66,750 shares of this Company is due to-morrow (Saturday).

ELMORE'S WIRE MANUFACTURING COMPANY.—A call of 10s. on 150,000 shares of this Company is due to-morrow (Saturday).

INDO-EUROPEAN TELEGRAPH COMPANY.—This Company has declared an interim dividend for the half-year ended June 30th last at the rate of 5 per cent. per annum.

SOUTH OF ENGLAND TELEPHONE COMPANY.—The Directors of this Company have declared a dividend at the rate of 6 per cent. per annum on the Preference shares for the half-year ending the 31st inst.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this Company for the week ending October 24, 1890, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,742.

WESTERN UNION TELEGRAPH COMPANY.—The annual report of the President of the Western Union Telegraph Company for the year ended June 30, 1890, shows that the capital stock outstanding is $86,199,852, of which $26,243,000 is in the treasury of the Company. The bonded debt, less sinking fund, amounted to $14,779,528. The business of the year shows:—Revenue, $22,387,028; expenses, $15,074,303; profits, $15,924,126, of which $10,052,983 remains as surplus. The profits show an increase of $1,091,683, as compared with the previous year. The average cost per message to the Company was 22·7c., as against 22·4c. the year before. There has been no increase in rates, but material reductions, the route west of the Mississippi receiving the larger share of the reductions. The additions to the plant were 5,163 miles of line and cables, 3,300 miles of wire, and 912 new offices, at a cost to the Company of $1,778,314, which was paid out of the surplus earnings.

THE NON-CONDUCTOR OF ELECTRICITY.

WAREHOUSE.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.

FACTORY.

MOSSES & MITCHELL, 70, Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Previous Week's Price, Oct. 22.	Price Wednesday, Oct. 29.	Rate per Cent. Yielded.	Dividend Due.	Business Done During Week Ending Oct. 29. Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
1,381,380	Stock	15/0	Anglo-American	49 50	48½ 49½	5 16 2	Jan., Apr., July, Oct.	49½	48½
2,309,310	Stock	30/0	Do. Preferred	85 86	84½ 85½	6 14 6	" "	85½	85
2,309,310	Stock	..	Do. Deferred	13¼ 13¾	13 13¼	..	.. ..	13¼	13⅞
25,000	£100	4%	African Direct, 4 per Cent. Debentures	99 102	99 102	3 18 5	January and July ..	..	..
130,000	10	3/0	Brazilian Submarine xd and Bonus	11¾ 12¼	11¾ 11¾	5 10 8	Mar., June, Oct., Dec.	12¼	11⅞
84,500	100	5%	Do. 5 per Cent. Bonds	100 102	100 102	4 18 0	January and July ..	..	..
75,000	100	8½	Do. 5 per Cent. Bonds (2nd Series)	103 107	103 107	4 13 6	June and December	105½	105
$7,216,000	$100	..	Commercial Cables	102 104	102 104	5 15 5	April and October ..	..	..
£16,000	£10	8/0	Cuba Submarine	11½ 12	11½ 12	7 1 8	February and August	..	..
6,000	10	10%	Do. Preference 10%	17 18	17 18	5 11 1	" "	..	..
12,931	5	2/4¾	Direct Spanish (£4 paid)	3¾ 4¼	3¾ 4¼	5 12 11	April and October..	..	..
6,000	5	10%	Do. Preference 10%	9 10	8½ 9½	5 5 3	April and October..	9	8½
60,710	20	3/6	Direct United States xd	10⅝ 10⅝	10½ 10½	6 13 4	Jan., Apr., July, Oct.	10⅝	10⅜
400,000	10	2/6	Eastern	13⅜ 14½	13⅜ 14	4 12 10	" "	14½	13⅜
70,000	10	6%	Do. 6 per Cent. Preference	14⅜ 15½	14½ 15½	3 18 8	" "	15	14⅛
1,200,000	Stock	4%	Do. 4 per Cent. Mort. Debenture Stock.. xd	104 107	103 106	3 15 6	May and November	107	..
200,000	£100	5%	Do. 5 per Cent. Debentures, 1899	106 109	106 109	4 11 9	February & August	107	..
250,000	10	2/6	Eastern Extension	14⅛ 14⅜	14 14½	4 18 3	Jan., Apr., July, Oct.	14½	14
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	100 102	100 102	5 17 8	February & August	..	..
91,800	100	5%	Do. 5 p. c. (Austn. Gov. Sub.) Debs. 1900	102 105	102 105	4 15 3	January and July ..	104	..
145,300	100	5%	Eastern & S. African 5 per Cent. Mor. Deb., 1900..	101 104	101 104	4 16 2	" "	102¾	..
180,227	10	1/9	Globe Telegraph and Trust	8¾ 9	8¾ 9	5 8 4	Jan., Apr., July, Oct.	9	8⅞
180,042	10	6%	Do. 6 per Cent. Preference	14½ 14¾	14½ 14¾	4 1 4	" "	14¾	14½
150,000	10	5/0	Great Northern	15¾ 16¼	15¾ 16¼	4 12 4	Jan., April, and July	15⅛	..
15,000	100	5%	Do. 5 per Cent Debentures, 1881	101 104	101 104	4 16 2	January and July ..	..	..
230,000	100	5%	Do. 5 per Cent. Debentures, 1883	104 107	104 107	4 13 6	March & September	..	..
17,000	25	37/6	Indo-European xd	36 38	35 37	6 15 2	April and October ..	..	..
38,348	10	4/0	London Platino-Brazilian	6½ 7½	6½ 7½	5 6 8	.. ..	..	..
100,000	100	6%	Do. 6 per Cent. Debentures	105 108	105 108	5 11 1	March & September	..	..
9,000	8	4/0	Reuter's	8¼ 8¾	8½ 8¾	5 14 4	May and November	..	..
3,381	£100 Cert.	6%	Submarine Cables Trust x April Coupon, 1890	110 114	110 114	5 5 3	" "	112	..
15,609	£10	6/6	West African	8½ 9½	8½ 9½	5 5 3	March & September	..	..
290,000	100	5%	Do. 5 per Cent. Debentures	98 101	98 101	4 19 0	April and October..	100	99½
30,000	10	3/0	West Coast of America	4½ 5	4 5	10 0 0	January and July ..	..	..
150,000	100	8%	Do. Debentures 8%	102 107	102 107	7 9 7	June and December	103¾	..
88,321	10	Nil.	West India and Panama	2¾ 3¼	3 3¼	.. ..	.. ..	3⅞	3⅛
34,563	10	6/0	Do. 1st Preference 6%	11½ 12	11½ 12	5 0 0	May and November	1⅛	11⅜
4,669	10	27/6	Do. 6 p. c. 2nd Pref.	14 15	14 15	4 0 0	" "	14½	..
64,174	15	6/0	Western and Brazilian	11 11¾	11 11½	5 4 3	" "	11⅜	11½
27,873	7½	1/6	Do. 5 per Cent. Cumulative Preferred	6¾ 6¾	6¾ 7	..	..	..	..
27,873	7½	4/6	Do. 5 per Cent. Deferred	4½ 5	4½ 5	..	..	..	..
200,000	100	6%	Do. 6 per Cent. Debs., Series "A"	103 106	103 106	5 13 2	February & August	..	..
230,000	100	6%	Do. 6 per Cent. Mort. Debs., Series "B"	103 106	103 106	5 13 2	" "	..	..
$1,336,000	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	122 127	122 127	5 10 3	May and November	..	..
£75,100	£100	6%	Do. 6 per Cent. Sterling Bonds	99 103	99 103	5 16 6	March & September	..	..
			TELEPHONES.						
224,850	14/0	0/5¾	Consolidated Telephone Const. & Maintenance. xd	⅛ ⅜	⅛ ⅜	..	May and November	⅛	..
220,000	£1	..	Oriental (11s. paid)	⅛ ⅜	⅛ ⅜	4 8 3	Yearly	..	..
438,984	5	3/0	National	4½ 4¾	4½ 4¾	6 13 4	June and December	4⅝	4½
15,000	10	6/0	Do. 6 per Cent. Cumulative 1st Pref.	12 12½	12 12½	4 16 0	June and December	..	..
15,000	10	4/9⅜	Do. 6 per Cent. Cumulative 2nd Pref.	9½ 10⅛	9½ 10⅛	5 14 3	June and December	..	..
209,750	1	..	South of England, Ordinary	⅛ ⅜	⅛ ⅜	..	..	..	..
20,000	5	2/0	Do. 6 per Cent. Cumulative Pf. (£3 10s pd).xd	2½ 3	2½ 3	..	..	..	..
58,000	5	1/0	United River Plate	3 4	3 4	..	January and July ..	..	..
116,128	Stock	..	Do. 5 per Cent. Debenture Stock	90 94	90 94	5 6 5	..	..	..
3,200	100	..	Do. 7 per Cent. Debentures	.. ..	.. ..	..	..	..	..
			ELECTRICITY SUPPLY COMPANIES.						
200,000	£5	..	London Electric Supply	2⅜ 2⅝	2⅜ 2⅝	..	..	..	..
43,900	10	..	Metropolitan Electric Supply (£8 paid)	5 5½	4¾ 5¼	..	..	5¼	5½
42,853	5	..	Westminster Electric Supply (£3 paid)	2¼ 3	2¼ 3	..	..	..	..
			ELECTRIC MANUFACTURING, &c., COMPANIES.						
63,416	3	..	Brush Electrical Engineering	1¼ 1¾	1¼ 1¾	..	..	..	..
63,416	2	0/10	Do. 6 per Cent. Preference	1½ 2	1½ 2	6 0 0	June and December	..	..
20,000	5	..	Crompton and Co., 7 per Cent. Pref. Shares	5½ 5¾	5½ 5¾	6 1 9	January and July ..	..	..
17,139	5	..	Edison and Swan United	.. ..	.. ..	..	..	..	..
45,000	10	..	Electric Construction	7½ 8	7½ 8	..	..	7¾	7⅜
70,000	2	10/0	Elmore's Patent Copper Depositing	5 5½	5 5½	..	..	6	4½
20,000	5	..	Fowler-Waring Cables (£4 paid)	2½ 3½	2½ 3½	..	..	..	..
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works...	18½ 19¼	18½ 19½	5 2 7	February & August	18⅝	18½
200,000	100	4½%	Do. 4½ per Cent. Debentures, 1896	100 102	100 102	4 8 3	March & September	..	..
78,949	5	6¾	Swan United (£3. 10s. paid)	5½ 5¾	5 5½	3 16 5	May and November	5⅝	5½
37,350	12	12/0	Telegraph Construction and Maintenance	43 45	43 45	5 6 8	March and July.....	45	44
150,000	100	5%	Do. 5 per Cent. Bonds, red. 1894	100 102	100 102	4 18 0	January and July ..	..	..

JABLOCHKOFF'S

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(BEING A PATENT FOR "PRODUCING AND DIVIDING ELECTRIC LIGHT," No. 1996 of 1877.)

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